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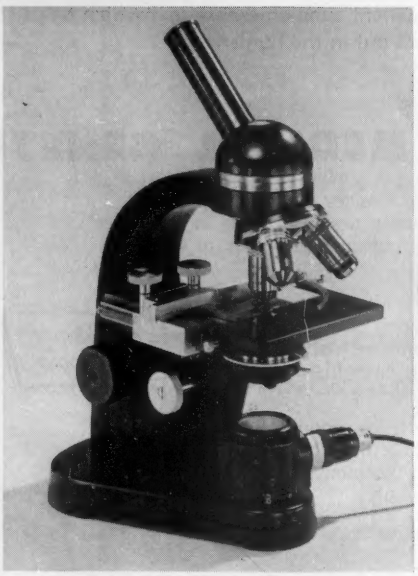

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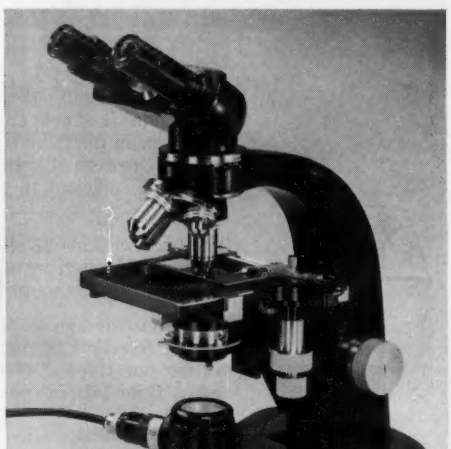

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Articles on Radiocarbon Dating

Since 1947 *Science* has played a large part in the publication of articles on the radiocarbon method of dating organic remains. However, the recent marked increase in the number of laboratories at work in this field and the corresponding increase in the number of radiocarbon lists has made it necessary for the Editorial Board to reconsider its publication policy.

During the years immediately after 1947 the radiocarbon dating laboratory at the University of Chicago, under the direction of Willard F. Libby, occupied the field alone. The Chicago group published several papers in *Science* on cosmic radiation and radiocarbon, on radioactivity of living matter, and on the radiocarbon method of estimating age, and, in 1951, the first extensive list of radiocarbon dates. In the same year the first similar paper from the newly established laboratory at Columbia University was published in *Science*.

Subsequently, several additional laboratories for radiocarbon dating were established in this country and in Europe. Inasmuch as *Science* had come to be regarded as the archival journal in this field, it was the journal of choice for publication of almost all of the results from the various laboratories. From 1951 through 1956, 18 articles on radiocarbon dating appeared in *Science*: from the Chicago group, 5 articles; Columbia, 3; Yale, 2; Copenhagen, 2; U.S. Geological Survey, 3; Pennsylvania, 2; and Michigan, 1. So far in 1957 two articles from the Humble Oil Company Laboratories have been published, and the first article from the Heidelberg laboratory appears in this issue. Articles from Columbia, Groningen, Stockholm, Yale, and Arizona await publication. The U.S. Geological Survey will soon submit its fourth list.

It is clear to the board that the increase in the number of papers in this field makes it impossible for *Science* to continue to publish radiocarbon articles in full. Perhaps the best solution—and indeed the usual solution in comparable specialized fields in the past—would be for those interested to establish their own journal. Nevertheless, in view of our close association with radiocarbon dating, the board sought some way to make it possible for us to continue to serve as a medium for the publication of radiocarbon papers, if those concerned wished to take advantage of it. The existence of the Auxiliary Publications Project of the American Documentation Institute permits an alternate solution.

Radiocarbon lists received on or after 1 October 1957 will no longer be published in full as lead articles, but will, if acceptable, be published as reports without dating lists. These reports will serve to describe the scope of the dating done and will provide a citation to the dating lists, which will be permanently stored in the American Documentation Institute, Auxiliary Publications Program, the Library of Congress. Each report will carry a notice that will give details about how photocopies of the lists may be obtained. This form of publication will make the radiocarbon dates permanently available to all who are interested and will make it possible for *Science* to continue to play an important part in making known the results of radiocarbon dating—results that are of interest to scientists in fields as diverse as archeology, geology, and prehistory.—G. DuS.

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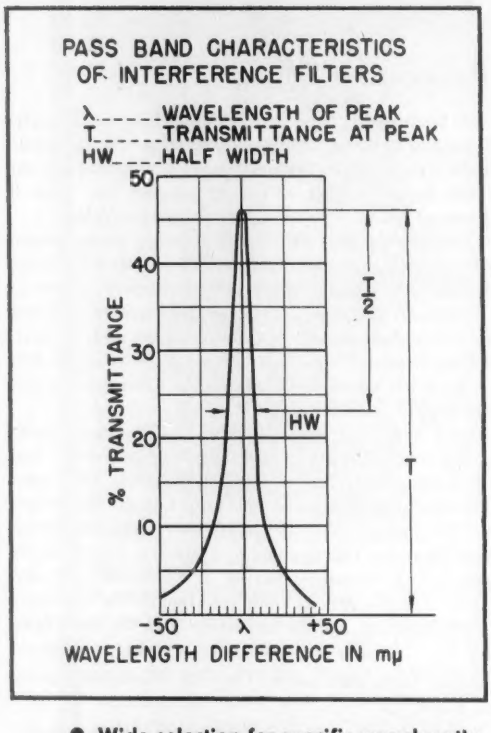

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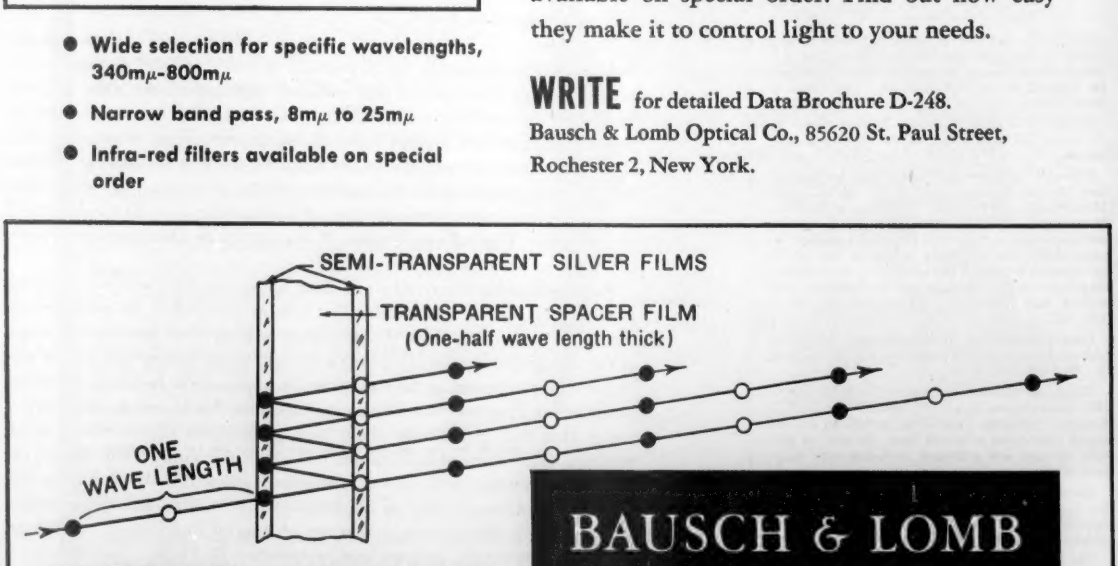

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Genetic Loads in Natural Populations

Theodosius Dobzhansky

In every age there have been those who believed that mankind manages its affairs badly and that it faces a bleak future. Ours is the "age of anxiety," and fears are probably more widespread than they used to be. Certainly the fears go deeper. Even the gloomiest prophets of old held that, no matter what disasters may come, human nature will continue to be pretty much what it has always been. But the prophets of today believe that human nature itself is endangered, since the biological endowment of mankind is in decay.

The prophets of today may be right. The human race may be a failure. Man has become powerful enough to destroy himself. However, we should not accept the dire prophecies without careful scrutiny. The situation may not be beyond repair. It may also not be amiss to note that our understanding of human nature, and of the natures of other forms of life, is not quite sufficient to formulate a reliable prognosis. Many biologists hope that a better understanding might be helpful, and that it could be achieved through investigation of the natures of living species which are more accessible to such investigation than that of the human species is. But these hopes collide head-on with the not unreasonable doubt whether much light can be shed on the nature of man by studying anything other than man himself.

Anaximander of Miletos proclaimed, some 2500 years ago, that man was biologically unique. Anaximander thought that all living creatures except man arose by spontaneous generation from mud warmed by sun rays. Man alone developed by transformation from other organisms. The issue is still joined. Having examined all the biases, pitfalls, and sources of error, a human geneticist recently proved that man is, after all, not an overgrown *Drosophila* fly, and not even an overgrown mouse. We concur in his conclusion. Biologists have at times made themselves ridiculous by talking about man as though he were nothing but an animal. Man's human properties make him biologically unique. Even different species of *Drosophila* are not alike in their biological natures. It would be odd indeed if man had no genetic peculiarities.

The incontrovertible fact is, however, that in many ways man does resemble other life. Man is a sexually reproducing, outbreeding species. So are mice and most drosophilae. This imposes profound similarities on human, drosophiline, and murine biological natures. It is as unreasonable to overlook these similarities as it is to ignore man's uniqueness. Among the inevitable consequences of being a sexual, diploid, and outbreeding species is that man, as well as *Drosophila,* is burdened with loads of deleterious mutants. Under some circumstances, these mutants produce hereditary diseases, malformations, and constitutional weaknesses in their carriers.

Origin

It is not my purpose here to set forth in any detail the story of the origin of the mutational loads. However, the essentials are simple enough. Mutations are alterations of the hereditary materials which occur presumably in every living species. We do not know just why most mutations arise, and to conceal our ignorance, we call them "spontaneous." Thus far, genetics has found no effective means to diminish the frequency of the occurrence of spontaneous mutants. But it has discovered ways to increase their frequencies by high-energy radiations and by other mutagens. This is unfortunate, because increased frequency of mutations in the human population may endanger man's biological future.

Most mutations are more or less injurious to the organism. It is not hard to see why this should be so. The injurious character of most mutants is not an attestation of inherent perverseness of nature. A change in a gene is expected to be injurious for the same reason for which random rearrangement of wires in a radio set would spoil it more often than improve it. Moreover, most mutations which we observe today have occurred many times before we started to look for them, and the ones which were useful instead of detrimental have become established like the correct wiring in the radio set.

Magnitude

Data more precise than those now available are needed concerning the frequencies of mutations in different organisms, from *Drosophila* to mouse to man. But such data alone would not tell us as much as we should know about the genetic economy of the respective species, just as figures on the import of raw materials from abroad would not alone be sufficient to understand the economic life of a country. One must find out what happens to the mutants after they invade the collective genetic endowment, the gene pool, of a population. Here we enter a field very little explored and possibly fraught with surprises.

Table 1 gives an idea concerning approximate magnitude of the load of mutations borne by natural populations of a species of *Drosophila* native in western United States and in Mexico (*1*). It may be noted parenthetically that even such crude approximations would have seemed impossible of attainment until recently, and that they are now available for only some species of *Drosophila.*

The author is professor of zoology at Columbia University, New York, N.Y. This article is based on a paper presented before the National Academy of Sciences as part of a symposium on radiation hazards that was held 22 April 1957 in Washington, D.C.

Comparable data for man are not yet within the range of what is possible. They could be obtained in corn and in a few other organisms, but this has not yet been done.

Table 1 discloses a startling situation. Between a fourth and a third of each of the chromosomes investigated are lethal or semilethal to homozygotes; that is, they kill all or most of their carriers if they are present in duplicate. Among the chromosomes free of lethals and semilethals, from 40 to 95 percent are subvital when homozygous; that is, they cause relatively milder hereditary diseases or impairments of the organism's vitality. From 4 to 18 percent of the chromosomes do not kill their homozygous carriers physically but kill them genetically; either the males, or the females, or, rarely, both sexes are completely sterile. It may be noted that genetically caused sterility among flies, like that among human beings, is often not accompanied by any noticeable impairment of body vigor. A genetic death does not always produce a cadaver.

It should be kept in mind that flies, like men, are diploid; a fly has the second, the third, and the fourth chromosome each represented twice. It can be shown by simple calculation from the data in Table 1 that the genetic endowment of 85 percent of individual flies includes one or more chromosomes which would kill their carriers if these chromosomes were present in double dose. More than half of the flies carry at least one chromosome which in homozygous condition would make either the females or the males sterile. Finally, all except a quite negligible minority of the flies carry one or more, mostly several, chromosomes which would incapacitate the homozygotes in various ways and in varying degrees short of semilethality. Since man, like *Drosophila*, is a sexually reproducing species, there is every reason to think that our load of mutations is hardly lighter than that of *Drosophila*; it may even be heavier.

Table 1. Percentages of the chromosomes in natural populations of *Drosophila pseudoobscura* which produce certain effects when in double dose (*1*).

Effects in homozygotes	Second chromosome	Third chromosome	Fourth chromosome
Lethal or semilethal	33	25	26
Subvital	93	41	95
Supervital	0.1	0.7	0.1
Female sterility	11	14	4
Male sterility	18	11	12

Effect on Fitness

If our genetic endowment is as replete with potentially morbid genetic factors as that of *Drosophila* is, this may seem to bear out the gloomiest forebodings of the decay of human nature. However, the remarkable fact is that the species of *Drosophila* whose genetic endowment is in this seemingly alarming condition is very successful in nature; it is certainly not a species approaching extinction. Moreover, it is a species living under "natural" conditions, not one grown effete because it has been pampered by civilized living. Apparently equally great loads of mutations, which would be staggering in the homozygous condition, have been found also in the few other flourishing species of *Drosophila* that have been examined in this respect. Strange as it may seem, the only known species which carries a markedly smaller load is *Drosophila prosaltans*, a rare, ecologically specialized form, which occurs spotwise in the American tropics without anywhere being the dominant species (*2*). Mention of the brilliant work of Wallace (*3*) is also relevant at this point. His experimental populations of *Drosophila* which acquired very heavy mutational loads owing to exposure to gamma rays of radium failed to show anything like a proportional reduction of their fitness.

The existence of populations seemingly saturated with injurious mutants, and yet highly successful in the struggle for life, is not as baffling as it may appear. Since heterozygous carriers of destructive recessive genes may be highly fit, the breeding structure of populations of some species sedulously provides to compensate for the load of detrimental recessive mutants by making most individuals in the populations heterozygous. Theoretically, a highly fit population may be obtained in either one of the following two extreme ways. First, the population may consist entirely of homozygotes for genetic factors which condition satisfactory fitness. Second, every chromosome in a highly fit population may be lethal in double dose, and yet it may yield high adaptedness in heterozygous combinations with all other chromosomes contained in the gene pool of the population. Of course, these extreme situations are rare in nature, if they occur at all; most populations will probably be found to have various intermediate structures. There is no way at present to tell what genetic architectures will be encountered in man or in various other organisms. This is an almost unexplored field. Although there are many difficulties in the way of such investigation, there is as much reason to study comparative genetics as there is to study comparative anatomy and comparative physiology.

The central problem posed by the existence of genetic loads in natural populations may be stated thus: What are the effects of these loads on the fitness of their carriers, given the breeding structure which the species normally has? A fearful mass of diseases and malformations would certainly appear if brother-sister mating were the normal means of reproduction in populations of *Drosophila* and of man. But incest is probably rare in most *Drosophila*, and even rarer in man. Outbreeding being the norm, the heterozygous carriers of harmful recessives are at least tolerably well off.

What may be called the classical hypothesis of genetic population structure holds that the genetic load is nothing but an unavoidable evil. The adaptively desirable condition is envisaged as homozygosis for genes giving high fitness. The genetic load results from a less than perfect efficiency of natural selection. Some generations elapse between the origin and the eventual elimination of a mutant from a population. The greater the load, the worse off the population. If mutation ceased to occur, populations would eventually throw off the load, would become homozygous, and would thereby gain in fitness.

There is every reason to think that the classical hypothesis is valid to some extent. It is obvious that mutants which cause dominant hereditary diseases, malformations, or diminished vigor detract from the fitness of their carriers. Furthermore, many recessive mutants which are lethal or strongly morbid when they are homozygous are debilitating to some extent also when they are heterozygous. Complete recessivity is not as common as genetics textbooks lead us to believe. Wright and I (*4*) inferred that recessive lethal mutants found in natural populations of *Drosophila pseudoobscura* cause slight but perceptible decreases of vigor when they are heterozygous. In 1952, this was demonstrated by Cordeiro (*5, 6*) and by Prout (*7*) for lethals in natural populations of *Drosophila willistoni*, by Stern and collaborators (*8*) for newly arisen lethal mutants in *Drosophila melanogaster*, and by Wallace (*9*) for lethals in irradiated populations of the same species.

Whether the classical hypothesis gives a valid account of the dynamics of natural populations may, however, be questioned. This would be correct only if there were no adaptively ambivalent mutants, deleterious under some conditions but favorable under others. Consider again the astonishing fact that almost every chromosome found in natural populations of *Drosophila pseudoob-*

scura is to some extent damaging in double dose. One may, to be sure, take refuge in saying that almost every chromosome normally contains several harmful recessive mutants which natural selection has not had time to eliminate. But to say this is to extend the term *recessive mutant* to a degree which makes it actually meaningless. What would a *Drosophila* and a man be like if they did not carry such recessive mutants? Perhaps they would be a superfly and a superman, but the fact is that such prodigies have never existed on earth. The species *Drosophila pseudoobscura* and *Homo sapiens* have been molded in the process of evolution as Mendelian populations which carry mutational loads. The adaptive norm of a sexual species has always consisted of individuals which carried in heterozygous condition genetic variants which would be destructive in double dose (*2*). The possibility must be considered that some degree of heterozygosis for mutants deleterious in homozygous condition may not be incompatible with high fitness in sexually reproducing species. This assumption is the essence of the balance hypothesis of population structure.

The mathematical theory of population genetics long ago demonstrated that if a heterozygote for a pair of genetic factors has an adaptive value higher than both homozygotes, then natural selection will maintain both factors in the population indefinitely. This is called balanced polymorphism, and it will also occur if the homozygotes are badly incapacitated or even lethally affected. Indeed, evidence has accumulated that balanced polymorphism is important in natural populations of *Drosophila*. There is some evidence (*10*) that balanced polymorphism also occurs in human populations, although there is no way at present to determine how widespread it is. The sturdiest *Drosophila* flies and sturdiest men may be products of hybrid vigor or heterosis. Farmers have good evidence that this is the case in highest yielding corn.

Illustrations

The evidence obviously cannot be set forth here in full, but some illustrations may be in order. Natural populations of many species of *Drosophila* vary in what may seem to be a tantalizingly recondite trait, the arrangement of genes in their chromosomes. In a part of central Brazil, an individual of *Drosophila willistoni* is heterozygous, on the average, for nine inversions in its chromosomes (*11*). Experiments with this and some other species of *Drosophila* have shown that inversion heterozygotes are in most environments superior in fitness to homozygotes. In Californian *Drosophila pseudoobscura* the relative fitness of carriers of certain chromosomal inversions is exquisitely sensitive to changes in the environment. The adaptive value of a certain heterozygote is more than twice that of a homozygote at 25°C, but if the temperature is lowered by only 9°, to 16°, the two become equal within the limits of experimental discrimination (*12*). In *Drosophila tropicalis* from one locality in Honduras, about 90 percent of the adult flies are heterozygotes for a certain chromosomal inversion (*13*). Since, among the eggs which these flies deposit, the homo- and heterozygotes are about equally frequent, it follows that most homozygotes die before they reach the adult stage. This might seem to be an appallingly inefficient situation for a population in nature to be in, and yet this population appears to be quite prosperous.

Table 1 shows that, although most chromosomes in *Drosophila pseudoobscura* are clearly deleterious in double dose, a small minority, less than 1 percent, are supervital. Flies homozygous for a supervital chromosome are more viable in the experimental environment than is an average fly which carries two different chromosomes. Here, one might think, we have found some normal chromosomes, unspoiled by mutation. Experiments of Spassky, Pavlovsky, Levene, and myself (*14*) have shown that this is not so. The supervital homozygotes are narrow environmental specialists. They retain their vigor only in a small range of environments, and their fitness deteriorates, often drastically, when the environment is changed.

Nor is it true, as has been surmised, that, in a given environment, normal and supervital chromosomes will be better in heterozygotes than the subvital chromosomes will be. This surmise was a reasonable one to make in view of the demonstration that recessive lethals tend on the average to be deleterious in heterozygotes. Experiments failed to vindicate the surmise. Heterozygotes which carry two different subvital chromosomes, or two different supervital, or one subvital and one supervital, are on the average equal in fitness. The key word in the last sentence is *average*, because different combinations of chromosomes do not have equal fitness. This is what agriculturists call "specific combining ability"; two inbred lines of corn, both lacking vigor, may give a vigorous and high-yielding hybrid. It may be noted at this point that by no means all chromosomes which are lethal in double dose are deleterious in heterozygotes, although they are so on the average. Stern and his collaborators (*8*), as well as Cordeiro (*5*) and Wallace (*9*), all found some recessive lethals which were heterotic in compounds with certain other chromosomes.

A part of the genetic load consists, then, of genetic variants which give hybrid vigor in single dose and yet are debilitating in double dose. These variants belong unmistakably to the genetic burden or "load" which the population carries, insofar as they weaken, incapacitate, or even kill the homozygotes. However, from the standpoint of population dynamics, there is an important difference between such variants and variants which are harmful or at least neutral in heterozygotes. The supply of the latter is maintained in the populations by the pressure of the mutation process; the frequency of the former is regulated chiefly by natural selection. Perhaps one should distinguish an unconditionally deleterious mutational load and a balanced load of mutations.

The discovery of the balanced load may seem to contradict the statement at the beginning of this paper, that most mutations are injurious to their carriers. There is no contradiction. Newly arisen mutants are much more likely to be unconditionally deleterious than are the mutants which have persisted in the populations for many generations. The simplifying assumption that newly arisen mutants, particularly those induced by exposure to high-energy radiations, merely add a qualitatively similar increment to the existing genetic load is no longer tenable. The genetic load which a sexual population carries is a compromise struck by natural selection between the adaptive requirements of the species and the mutation pressure. Many mutations which arise spontaneously, and *a fortiori*, mutations induced by mutagens not usually encountered by the species, do not pass the scrutiny of natural selection.

Conclusion

Any increase of mutation rates in human populations would add an increment to the store of human misery. If anything, radiation-induced mutants are more destructive than the spontaneous ones. As far as genetic effects are concerned, the only safe dose of high-energy radiation is no radiation. But beyond this, perhaps the most important lesson which the work on genetics of natural populations has taught us is one of humility. A satisfactory theory of population dynamics is not yet available. More data are needed on practically every aspect of populations genetics.

The genetic forces which impinge on human nature are not sufficiently under-

stood for us to judge whether this nature is endangered, and if so to appraise how great the danger really is. Populations of various organisms will have to be studied. Of course, man is one of them. But it can hardly be overstressed that different organisms are most favorable for investigation of different aspects of population genetics, and that progress would be obstructed or side-tracked by undue concentration. The way towards understanding of biological aspects of human nature may lead through such lowly creatures as mice, drosophila, and even viruses.

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Heidelberg Natural Radiocarbon Measurements I

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Radiocarbon age determinations made at the University of Heidelberg in the period between March 1954 and July 1956 are described in this article (*1*). Tables 1, 2, and 3 contain various calibration measurements; Tables 4 and 5, the age determinations. Proportional counting of carbon dioxide with a gas pressure of roughly 1 atmosphere was used in making the measurements.

The carbon-14 content of a sample was compared with that of an arbitrary recent standard. Our standard is based on wood of the 19th century—that is, on wood that grew before the dilution of carbon-14 in the atmosphere by the industrial combustion of coal and oil (see subsequent paragraphs). For the calculations, a value of 5568 years (*2*) was used for the half-life of carbon-14.

The error given (*3*) is the statistical fluctuation of the carbon-14 measurement; it does not take into account variations resulting from other causes such as small fluctuations in the carbon-14 content of different plants of the same age, the uncertainty of the half-life, and others. These other variations have not been investigated thoroughly enough, and it is difficult to estimate them exactly. Most of the systematic errors are either common to all carbon-14 measurements (uncertainty in the half-life of C^{14}), or at least to all measurements made by the same laboratory (different standards for recent carbon), and radiocarbon dates can easily be corrected for them if new information should prove that correction is necessary.

Because these errors are relatively small, they are unimportant for older samples. However, some of the younger samples have a statistical error of less than 100 years; in these cases, we propose that ±100 years be taken as the error if the figures are to be compared with historical dates, to allow for the afore-mentioned uncertainties.

The determinations listed in this article are numbered as follows: the first number following the letter H (Heidelberg) refers to the position in our sample list, and the second (after the hyphen) is the number of the specific determination.

Fossil organic material was usually treated only with hot, diluted acid, primarily to remove carbonates, but in addition, some samples were also treated with diluted alkali to remove humic acids.

The datings based on bone and antler seem to be unreliable. Even the organic fraction of bone frequently gives lower dates than the archeologic relationships allow. By "organic fraction" is meant the proteinic emulsion that is obtained after the finely ground bone has been dissolved in acid and purified by dialysis. The calcareous fraction of bone and antler (that is, the carbon dioxide generated by treatment with acid) shows even larger deviations from the true age, amounting to up to several thousand years in the case of old bones. Contamination by ground water seems plausible, considering the high carbon-14 content in the dissolved bicarbonate. The hard waters that we investigated (*4*) showed an apparent age of only 1000 to 3000 years.

We also consider it possible that the organic fraction has been contaminated by ground water. The C^{14}-active carbon dioxide in ground water is derived from the humus layer on the surface, and it is by no means impossible that sufficient organic material (*5*) to cause contamination is transferred by the water from this source and absorbed by the proteins in the bone. One cannot remove these absorbed substances from bone as easily as one can from wood, where the cellulose, which is for the most part insoluble, is treated with hot acids and bases and separated by filtering. Proteins, on the other hand, if treated in the same way, would themselves be dissolved. In the special case when the organic and calcareous fractions of a bone give the same age, the age can be accepted as correct, for it is very improbable that both fractions have undergone exactly the same amount of contamination.

Calibration Measurements

A series of carbon-14 determinations of wood dated exactly by dendrochronology has been made. With the age known, the loss of sample activity by radioactivity decay could be eliminated. Thus, after correction, each measurement gives a value for the activity of "recent carbon"—that is, the quantity A_0 in the decay law $A/A_0 = \exp.(-t/\tau)$ on which the calculation of radiocarbon ages is based (A is the measured activity of a sample today, t is the age of the sample, and τ is the mean life of carbon-14). The A_0 used in calculating the age values given is the mean of a preliminary set of measurements of this type. Further measurements shifted the mean slightly, but for practical reasons we have kept our original value of A_0 as a more or less arbitrary standard.

Table 1 contains the individual cali-

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bration measurements showing the percentage deviation from our standard. Although the deviation of the mean of all calibration measurements from the standard is insignificant and the agreement within the several groups is good, it should be stated that the groups differ from each other. We do not intend to go into details about the possible causes, but as can be seen, the definition of a recent standard is, within certain limits, arbitrary. A deviation of ±1 percent in the activity corresponds to a deviation of ∓80 years in the ages to be calculated. If we were to take as an extreme example the mean of our measurements on oak tree rings from the 16th century (corrected for age) as a standard, the carbon-14 ages we give would be higher by 100±27 years. On the other hand, the age we get with our present standard for the exactly dated samples of charcoal found at the Roman settlement of Heidelberg-Neuenheim (samples H169-210, H166-158, and H93-73) is already about 50±40 years too great. Under these conditions, there is a discrepancy of 150±48 years. We mention this only to show the extent to which the error in absolute age from this source may amount. But as has been mentioned already, such an error could easily be corrected for afterward by deducting, for example, 50 years from all carbon-14 ages given by this laboratory. Incidentally, such a correction does not increase with the age of samples and therefore primarily concerns young dates.

To be able to reproduce our recent standard easily we use carbon dioxide from a Na_2CO_3-solution with a specific carbon-14 content roughly 10 times that of recent wood.

Table 2 contains some measurements on modern plants. As in Table 1, the percentage deviation from our standard of recent carbon is given. The lower C^{14}-content of plants living in the 20th century can be ascribed to industrial combustion of coal and oil. The values obtained here are in agreement with those which Suess (*6*) made on plants from the East Coast area of the United States.

Table 3 contains some calibration measurements on bone and antler.

References and Notes

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Table 1. Determinations of wood dated by dendrochronology. All tree ring measurements with identical sample numbers (that is, the first number) came from the same tree. The samples were provided by B. Huber and W. von Jazewitsch. All activities were corrected for age. Percentage deviation of activity from recent standard is given in column 3.

Description	Sample	Deviation
19th century		
Oak, rings 1840 to 1850. This tree (No. 1220) came from the Spessart Forest; it contained rings from A.D. 1506 to about 1930.	H11-31	−0.82±0.47
Oak, rings 1840 to 1850.	H11-81	−1.81±0.52
Oak, rings 1840 to 1850. This tree (No. 1220/2) came from the Spessart Forest (Rothenbuch, Denkstein section); it contained rings from A.D. 1540 to 1948.	H55-147	−0.34±0.41
Fir, rings 1840 to 1850. This tree (No. N2/BW136) came from the Bavarian Forest; it contained rings from A.D. 1640 to 1950.	H12-47	+0.73±0.35
Fir, rings 1840 to 1850.	H12-80	+0.13±0.35
17th century		
Fir, rings 1675 to 1690.	H12-61	+0.91±0.35
16th century		
Oak, rings 1505 to 1525.	H11-29	+1.51±0.73
Oak, rings 1523 to 1539.	H11-198	+0.91±0.73
Oak, rings 1530 to 1560.	H55-50	+1.29±0.43
14th century		
Büdingen castle (Hessen). Beam of oak, rings 1382 to 1386.	H152-199	+0.47±0.78
Fürsteneck castle (Hessen). Beam of oak, rings 1362 to 1382.	H155-189	−0.26±0.69
Weighted averages		
(weight = statistical accuracy of each measurement)		
Oak, 19th century.		−0.90±0.27
Fir, 19th century.		+0.43±0.25
Oak, 16th century.		+1.25±0.33
Oak, 14th century.		+0.05±0.52
Weighted average of all measurements (= "wood before 1850").		+0.26±0.14

Table 2. Effect of industrial combustion of coal and oil on the specific C^{14}-activity of modern plants (compare Table 1). All activities were corrected for age. Percentage deviation of activity from recent standard is given in column 3.

Description	Sample	Deviation
Oak from the Spessart Forest (sample description is in Table 1). Wood from a layer under the bark, 1 mm thick; about A.D. 1930.	H11-69	−2.80±0.65
Birch twigs (1954) from the Kaltenhofener Moor 15 km north northwest of Kiel, provided by F. Overbeck.	H74-52	−3.15±0.6
Peat moss from the Kaltenhofener Moor, mostly *Sphagnum recurvum* from a bog (pH, 4.5), 1 year old in 1954; provided by F. Overbeck.	H78-58	−2.63±0.52
Samples from the limestone area (compare *4*) 50 km east of Heidelberg.		
Grass from an open site.	H160-187	−2.80±0.9
Moss from a ditch in a wood, a relatively badly ventilated site.	H162-162	−3.23±0.73
Branches from the same site as sample H162 growing about 2 m above the ground.	H161-177	−3.97±0.82
Weighted average of the C^{14} activity of modern plants (Weight = statistical accuracy).		−3.02±0.27

Table 3. Carbon-14 activity of bone and antler. All activities were corrected for age. Percentage deviation of activity from recent standard is given in column 3.

Description	Sample	Deviation
Palmed antlers of fallow-deer, about 50 years old, provided by E. Wohlfahrt. Organic fraction.	H135-111	−2.1±0.65
Recent bone from cattle (1956).	H179-171	−2.1±0.75

5. The measure commonly used for the content of organic substances is the "oxygen consumed." Pure drinking water generally has an "oxygen consumed" of up to 3 mg/lit. In the case of oxalic acid, this would mean an organic carbon content of 4.5 mg/lit. See Ohlmüller-Spitta, *Untersuchung und Beurteilung des Wassers und Abwassers* (Springer, Berlin, ed. 5, 1931), pp. 98 and 458.
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Table 4. Samples dated archeologically or by pollen analysis. The carbon-14 age is given in years plus or minus the root-mean-square error of counting (*7*).

Description	Sample No.	Age
I. *Europe*		
A. *Late Ice Age*		
Meiendorf, Holstein. Site of Older Hamburg culture, Oldest Dryas (pollen analysis by R. Schütrumpf), older than Poggenwisch (see samples H31 and H32). Collected by A. Rust; submitted by H. Schwabedissen.		
Porous branches of antler (compare *8, 9*) dissolved in hot HCl, one-half of the solution purified by dialysis ("organic fraction").	H38-121A	12,000 ± 200
The other half of the solution was evaporated without further purification.	H38-121B	12,300 ± 300
Carbonate fraction of the antler.	H38-121C	6150 ± 500
Poggenwisch, Holstein. Younger Hamburg culture. Pollen analysis by R. Schütrumpf (*10*): Oldest Dryas, before the Bölling oscillation. Collected by A. Rust; submitted by H. Schwabedissen. Compare sample W-271, 11,750 ± 200 yr (*8*).		
Bone, organic fraction.	H31-67	13,050 ± 270
Calcareous gyttja, carbon content 2.7 percent (organic fraction) plus 1.9 percent (calcareous fraction, corresponding to 16 percent $CaCO_3$).		
1) Residue after treatment with HCl and filtration; compare sample W-93, 15,150 ± 350 yr. (*11*). CO_2 from hard water assimilated by the water plants (*12*) probably caused a lower initial C^{14} content and therefore raised the apparent age.	H32-60	15,700 ± 350
2) Calcareous fraction. Because the apparent age of the chalk is even greater, it seems likely that the subsequent exchange of carbonate between gyttja and water (*4*) was comparatively low.	H32-118a	17,100 ± 560
3) Filtrate obtained from the same portion after treatment with HCl and purified by dialysis—that is, prepared in the same way as the organic fraction in the case of bone.	H32-118c	12,850 ± 500
Wood, small twigs, submitted by A. Rust.	H136-116	12,980 ± 370
Munzingen, Baden-Württemberg. Magdalenian culture layer in loess. Submitted by H. Schwabedissen. Antler, organic fraction. Corresponds to sample W-266, 10,100 ± 250 yr. (*8*). The age must be at least 11,000 to 12,000 yr.	H129-104	10,200 ± 250
Petersfels, near Engen, Baden-Württemberg. Well-known Magdalenian cave excavated by E. Peters; sample submitted by H. Schwabedissen. Antler, organic fraction. Compare with sample W-267, 8200 ± 200 yr. (*8*). The age is at least 10,000 to 12,000 yr.	H130-114	10,150 ± 230
Lake of Gatersleben, Middle Germany. Layers of peat from the first advance of birch trees after the last glaciation (Bölling-Interstadial). According to these measurements, the Bölling-Interstadial lies shortly before the Alleröd period, meaning that the Older Dryas between them lasted only a few centuries (*13*). Samples collected and identified by pollen analysis by H. Müller. Submitted by F. Firbas.		
Wood (*Salix, Betula*) found at a depth of 370 to 380 cm in a rush peat. According to pollen analysis, this sample dates from a time preceding or at the beginning of the Bölling period.	H88-74	13,250 ± 280
Wood from clay with organic sediments at 280 to 290 cm depth, 10 to 20 cm higher than the calcareous sediments belonging to the Bölling period. According to pollen analysis, this sample dates the beginning of Older Dryas (Ic).	H77-54	12,300 ± 260
Wood from the same peat as sample H88, also from immediately before or at the beginning of the Bölling period.	H106-89	12,700 ± 320
Wallensen im Hils. Peat sediments 0 to 2 cm above the layer of volcanic ash between the lake sediments of the Alleröd period. The sample dates the last big eruptions of the volcanic Lake of Laach (Eifel Mountains) and the Alleröd period. The sample has been dated by several laboratories, the results agreeing well (*14*). Submitted by F. Firbas.	H1-8 H1-48	11,900 ± 500 11,800 ± 300
Andernach (Rhine), Martinsberg. Magdalenian site (VIb). Submitted by H. Schwabedissen (*15*).		
Antler, organic fraction.	H85-91	11,300 ± 220
Bone, carbonate fraction.	H193-178	4330 ± 360
Rissen, near Hamburg. Layer from		

Description	Sample No.	Age
the Late Magdalenian culture (Federmessergruppe, *15*). The pollen age determined by R. Schütrumpf is Alleröd. Excavated and submitted by H. Schwabedissen.		
Carbonate-free gyttja sample from a horizon below the culture layer.	H21-18	11,550 ± 280
Wood from the gyttja.	H18-11	11,930 ± 290
Carbonized wood from the culture layer. Compare samples Y-157A and Y-157B, 10,560 ± 200 yr and 9280 ± 290 yr (*9*).	H75-68	11,450 ± 180
Ruds Vedby, Denmark. Wood from the boundary between the Alleröd and Younger Dryas. The reference sample was provided by J. Iversen. Compare sample K-101, 10,890 ± 240 yr. (*16*), and samples W-82 and W-84, 10,260 ± 200 yr and 10,510 ± 180 yr, respectively (*11*).	H105-87	11,500 ± 300
B. *Middle Stone Age*		
Geislingen-Steige, Württemberg, Rohrach Valley. Wood from the "Basismudde" covered by calcareous tufa and other postglacial sediments, representing the first sediments after the glaciation that are datable by pollen analysis. Pollen age, Preboreal. Submitted by P. Groschopf (*17*).	H126-143	9290 ± 190
Duvensee, Schleswig-Holstein. Mesolithic settlement. Pollen age determined by S. Schneider is Early Boreal (VIa). Excavated and submitted by H. Schwabedissen.		
Board with bark of birch from the floor of a hut.	H23-22	9200 ± 300
Hazelnut shells mixed with some carbonized wood. Compare sample Y-161, 8760 ± 70 yr (*9*).	H26-23	9030 ± 350
C. *Neolithic, Bronze, and Iron ages*		
Heidmoor, district of Berlin, Schleswig-Holstein. Neolithic moor settlement. Excavated and submitted by H. Schwabedissen. Compare samples Y-443-b and Y-443-e, 4530 ± 170 yr and 4400 ± 170 yr (*9*).		
Carbonized wood found 5 cm above the top culture layer, Glockenbecher culture, field 719a.	H27-25	3720 ± 150
Wood from 5 cm below the Glokkenbecher culture layer. Part of the piece was located inside the Glockenbecher stratum. Field 719c.	H28-33	3970 ± 170
Wood from field 719h. Early Trichterbecher culture.	H29-146	5140 ± 115
Charcoal from field 719h. Early Trichterbecher culture.	H30-145	5020 ± 105
Ehrenstein, near Ulm (Danube). Neolithic settlement containing Schussenrieder and Michelsberger ceramics. Archeological date 2000 B.C. (*18–20*). Should be older, according to pollen analysis (P. Groschopf): Late Eichenmischwald period. Submitted by P. Groschopf.		
Wood from a house.	H125-107	5200 ± 200
Another piece of wood (a) from this excavation.	H61-149	5140 ± 130
Grünhof-Tesperhude, Schleswig-Holstein. Charcoal from a tumulus, Middle Bronze Age, 1300 to 900 B.C. Collected by K. Kersten; submitted by H. Schwabedissen.	H40-34	3120 ± 160

Description	Sample No.	Age
D. *Roman, Medieval ages*		
Aachen. Cathedral. Planks of oak wood from 2.20 m depth below the cloister courtyard, presumably making up a fresh-water conduit of the Roman period (1st century A.D.). Submitted by F. Kreusch.	H54-44/54	2060 ± 90
Mainz. Beam of the Roman bridge over the Rhine discovered during reconstruction work on the present Rhine bridge. The Roman bridge definitely existed in the 1st century A.D.; it was destroyed and reconstructed several times and then disappeared about A.D. 300. Submitted by R. Immel through W. von Jazewitsch.	H59-57	2010 ± 60
Heidelberg. Roman settlement at Neuenheim. Samples collected and submitted by B. Heukemes.		
Beam from wooden support underneath the pillar of a stone bridge. This bridge was built, according to an inscription, at the close of the 2nd century A.D. The existence of an older wooden bridge at the same place during the close of the 1st century is very probable. The beam possibly originates from this older construction.	H94-72	2060 ± 110
7, Werderstrasse. Charcoal from a layer of iron slag found in the lower level of a Roman cellar (A) dated A.D. 70 to 80. Some larger pieces of charcoal have been identified as oak and beech (W. von Jazewitsch).	H169-210	1930 ± 80
2, Jahnstrasse. Charcoal, consisting mostly of carbonized pine needles, from a Roman garbage pit; about A.D. 100.	H166-158	1915 ± 65
93, Ladenburgerstrasse. Charcoal from pit C dating from the Trajan period, A.D. 100 to 110.	H93-73	1905 ± 65
8, Jahnstrasse. Bones from garbage pit A, organic fraction.	H91-71	2240 ± 70
Another portion of sample H-91.		
1) organic fraction.	H91-126a	1885 ± 80
2) carbonate fraction.	H91-126b	1260 ± 150
Groningen, Netherlands. Wood from the Saint Walburg Church. The reference sample was provided by H. de Vries. By using the standard for recent carbon at the time of measurement 2 years ago, we obtained an age of 1065 ± 130 yr (*21*), which agrees well with the dates obtained by other laboratories (the mean of a great number of determinations at Groningen was 1000 ± 60 yr). Our former standard was the C^{14} content of present-day wood, which was commonly used at that time. Meanwhile, to eliminate the effect of industrial combustion, we changed to the standard described in the text, which is the basis of all the determinations contained in this list.	H8-7	1245 ± 130
Höhbeck, Niedersachsen. Charcoal from the bottom of a ditch of this fortification. Carolingian age (*22*).	H87-76	1070 ± 80
Kassel. Brüderkirche. Beam of oak, mean age of the outmost rings. The rings were dated by C^{14} in order to make the work of dendrochronologic synchronization easier. The C^{14} age in this case is not based on our standard but was obtained by direct comparison with wood from the 16th and 19th	H63-36	508 ± 85

Description	Sample No.	Age
centuries. Meanwhile, dendrochronologically, the last ring has been dated at A.D. 1392 (*23*). Submitted by W. von Jazewitsch.		
E. *Recurrence horizons in German bogs*		
One of the recurrence horizons in German bogs is very striking. It is called the "Grenzhorizont" (C. A. Weber). Weber supposed it to be the result of a stoppage in the growth of the moor lasting about 1000 years. He dated the subsequent setting-in of a moister climate at about 800 B.C., according to the stratigraphic position of an archeologically dated human body found near the horizon. Later on, the Grenzhorizont was generally accepted as being of the same age as the Swedish RY III (600 B.C.). But there have been doubts about the simultaneity of all the horizons. According to our measurements, the recurrence horizons called Grenzhorizont and thought to be of equal age seem to be separated into three groups: at about 600 B.C., 100 B.C. and A.D. 650. The 100 B.C. group is the most strongly represented among the examples investigated so far. A longer interruption in growth we did not find (compare *9*). Measurements on peat samples either purified with alkali or unpurified show the reliability of C^{14}-determinations of peat under such circumstances, as do the dates from wood in the same stratigraphic position. This reliability was questionable. A more thorough description is given by Overbeck (*24*). Submitted by F. Overbeck.		
Rotes Moor, Rhön Mountains. 800 m above sea-level.		
Peat 0 to 2 cm above a younger horizon "RY II."	H70-102	1390 ± 120
Peat 0 to 2 cm below Grenzhorizont.	H67-49	2010 ± 80
Grosses Moor, near Gifhorn (Lüneburger Heide).		
Peat 0 to 2 cm above Grenzhorizont.	H72-88	2050 ± 110
Peat 0 to 2 cm below Grenzhorizont.	H71-85	2100 ± 100
Peat 4 to 6 cm below Potonié-Horizon.	H119-103	4040 ± 150
Hellweger Moor near Bremen.		
Peat 0 to 2 cm above Grenzhorizont; treated with alkali.	H171-163	2100 ± 65
Sprigs of *Calluna* from the horizon; treated with alkali.	H183-217	1965 ± 65
Peat 0 to 2 cm below Grenzhorizont; treated with alkali.	H182-203	2050 ± 75
Moor of Melbeck, near Lüneburg (2).		
Peat 0 to 10 cm above Grenzhorizont; treated with alkali. Compare sample C-449, 1129 ± 115 yr.	H163-156	1240 ± 60
Peat 0 to 10 cm below Grenzhorizont; treated with alkali. Compare sample C-450, 1449 ± 200 yr.	H164-160	1500 ± 80
Wittmoor, near Hamburg (25).		
Peat 0 to 2 cm above a younger horizon (a), unpurified.	H232-211	1185 ± 70
Wooden plank (oak) from the Younger Plankway lying in this horizon.	H231-204	1265 ± 55
Peat 0 to 2 cm below the horizon; treated with alkali.	H230-235	1360 ± 60
Wood from a stake, 5 cm thick, from the Older Plankway, lying 15 to 20 cm above Grenzhorizont.	H167-159	1840 ± 75
Peat 0 to 5 cm above Grenzhorizont; treated with alkali.	H89-70	2040 ± 50
Humic substances isolated from this sample.	H89-70a	2150 ± 75
Recheck, corresponds to H89-70; treated with alkali.	H89-135	2000 ± 65
Peat 0 to 2 cm above an older recurrence horizon (d); treated with alkali.	H165-157	2920 ± 65
Peat 0 to 2 cm below this horizon; treated with alkali.	H184-202	2915 ± 85
Doosenmoor, near Neumünster, Schleswig.		
Peat 0 to 2 cm above Grenzhorizont; treated with alkali.	H180-173	2560 ± 100
Peat 0 to 2 cm below Grenzhorizont; treated with alkali.	H181-181	2755 ± 100
Grosses Moor von Dätgen, near Neumünster, Schleswig.		
Peat 0 to 2 cm above Grenzhorizont, unpurified.	H150-139	2365 ± 60
Same sample treated with alkali.	H150-148	2460 ± 75
Sprigs of *Andromeda* and roots of *Eriophorum angustofolium* from the horizon; treated with alkali.	H148-128	2540 ± 100
Peat 0 to 2 cm below Grenzhorizont; treated with alkali.	H149-132	2690 ± 75
II. Iraq		
Uruk-Warka. Samples from excavations made by Deutsches Archäologisches Institut and the Deutsche Orientgesellschaft in 1954; submitted by A. Falkenstein.		
Remains of reeds from the deepest strata reached in the profile in Eanna lying on the natural soil. See Nöldeke *et al.* (*26*): "Well-preserved layers of reed" below the index "ground water level 1932."	H138-123	6070 ± 160
Wood from younger strata of temple of Ningischzida in Eanna. Neo-Babylonian or Seleukidian.	H139-129	2200 ± 90
Remains of reeds from layers of mats in the Ziqqurrat of Urnammu in Eanna; see Jordan (*27*, Figs. 9 and 10). The mat derives from the construction work under Urnammu, the first king of the 3rd dynasty or, at the latest, to that under his son and successor, Schulgi. Consequently, according to the chronological calculations of W. F. Albright, it dates to the period between 2070 and 2000 B.C. In order to extract any humic acids which could have infiltrated, the sample was treated with alkali.	H141-120/166	3825 ± 85
Ash with traces of charcoal from the oldest level of Bīt Akītu, from the court just outside the side-cella which is situated near the north corner of the court yard; see Lenzen (*28*, Table 2, room 36).	H142-133	2465 ± 170

Table 5. Dates of samples having an age known only within very wide limits.

Description	Sample No.	Age
Elbe River. Trunks of oak wood found during dredging at different places in the Elbe bed. Submitted by Wasser- und Schiffahrtsdirektion, Hamburg.		
Found in Sept. to Oct. 1954 at the 485.7-km point; length, 7 m; diameter, 0.4 m; 123 year rings.	H100-101	1930 ± 100
Found in Sept. to Oct. 1954 at the 473.7-km point; length, 8 m; diameter, 0.9 m; 112 rings.	H101-115	555 ± 90

Description	Sample No.	Age
Found in Oct. 1953 at the 572-km point; 53 rings.	H102-137	2000 ± 60
Burlafingen, Kreis Neu-Ulm. Oak trunk, 0.8 m in diameter, thought to have been worked in Neolithic times, from a gravel pit in the valley of the Danube under about 4 m of gravel. At the same place, an old valley floor, a great number of trunks have been found. Presumably a wood standing there was destroyed by floods (*29, 30*). Submitted by P. Groschopf.	H124-138	1850 ± 75
Lage in Lippe. Oak trunk, 0.5 m in diameter, discovered 4.5 m beneath the bottom of the valley in gravel thought to have been deposited during the Last glaciation. Nearby have been found an elk antler, heavily damaged by glacial movement, and a well-preserved skull of a horse which is similar (G. Nobis) to those known to have existed in Germany during the Iron Age and the Roman period. Submitted by O. Suffert.	H168-161	2950 ± 75
Saint Gallen, Switzerland. Remains of a prehistoric wood (*31*) containing 130 trunks, which have been identified, and further remains—for example, seeds—also identified. The ratio of the several species is to a large extent the same as in the natural composition of wood growing in such a location today. The wood was found in a shallow valley about 800 m above sea level; the drainage of the valley was checked by landslides. The valley became a moor, and the wood died. Submitted by H. Oberli.		
Fir with mistletoe from this valley. A C^{14}-determination of another sample from this trunk, in Bern, gave 3200 ± 130 yr (*32*).	H81-62	3040 ± 100
Beech buried in the landslide.	H104-90	3590 ± 130
Schruns, Vorarlberg, Austria. Spruce trunk found at 1700 m above sea level, together with trunks of other species, during construction work of a water power plant. The wood was found after a horizontal gallery had been bored for a distance of 85 m at an underground depth of 70 m. The trunks reached their present position as the result of a landslide. The ratio of the various species of wood found is essentially the same as it is in this locality today (A. Pisek). Submitted by Vorarlberger Illwerke A. G., Schruns. Three other wood samples from this place, dated in Bern, gave 5350 ± 140, 5500 ± 160, and 5500 ± 140 yr (*32*).	H122-100	5860 ± 150
Hredavatn, Iceland. Peaty layer in sediments linked with layers of lava. The eruptions are very likely younger than the peat layer. Submitted by M. Schwarzbach (*33*).	H146-124	3700 ± 120
Heidelberg, bone of a mammoth, discovered during construction work about 1 m deep in a calcareous loess. The age obtained is too small, for mammoths became extinct several thousand years earlier.		
Organic fraction.	H145-117	7480 ± 200
Carbonate fraction; compare Münnich (*4*).	H145-127	3370 ± 90

News of Science

Pugwash Statement

At the invitation of British philosopher and author Bertrand Russell, and through the hospitality of Cyrus Eaton, Cleveland industrialist, a group of scientists, drawn from about ten nations and widely representative of different political, economic, and other opinions, met in a conference at Pugwash, Nova Scotia, between 6 and 11 July. The meeting originated in the suggestion contained in the Russell-Einstein appeal, made 2 years ago, that scientists should meet to assess the perils to humanity which have arisen as a result of the development of weapons of mass destruction.

The following scientists participated in the conference: M. L. E. Oliphant, physicist, director of the Post-graduate Research School of Physical Sciences, National University of Australia, Canberra; H. Thirring, physicist, University of Vienna, author of *Theory of Relativity and Einstein Theory*; G. Brock Chisholm, physician, Victoria, B.C., former director general of the United Nations World Health Organization; Chou Pei Yuan, vice rector of Peking University; A. M. B. Lacassagne of l'Institut du Radium, Paris; C. F. Powell, Nobel laureate in physics of the H. H. Wills Physical Laboratory at Bristol, England; J. Rotblat, executive vice president of the Atomic Scientists' Association and physicist at the University of London; I. Ogawa, professor of Tokyo's Rikkyo (St. Paul's) University; H. Yukawa, Nobel laureate in physics and director of the Research Institute for Fundamental Physics, Kyoto University; S. Tomonaga, physicist, Tokyo University of Education; M. Danysz of the University of Warsaw, Poland; D. F. Cavers, associate dean of the Harvard Law School; H. J. Muller, Nobel laureate in physiology, geneticist and professor of zoology at Indiana University; P. Doty of the department of chemistry, Harvard University; E. Rabinowitch of the University of Illinois, editor of *Bulletin of the Atomic Scientists*; W. Selove, physicist, University of Pennsylvania; V. Weisskopf of Massachusetts Institute of Technology; A. M. Kuzin of the U.S.S.R. Academy of Sciences; D. F. Skobeltzyn of the U.S.S.R. Academy of Sciences, director of T. N. Lebedev Institute of Physics, Moscow; A. V. Topchiev, chemist, head of the Institute of Silicates, U.S.S.R. Academy of Sciences.

These men all signed the "Pugwash

Statement," most of which is quoted here.

"The international problems which have arisen as a result of the development of atomic energy are of two kinds, technical and political. A gathering of men of science can discuss with special competence only the scientific and technical implications of atomic energy. Such discussion, however, can be fruitful only if it takes into account the political problems which are the background to international negotiations. The signatories of the Russell-Einstein appeal affirmed their intention to say nothing which might seem to favor one rather than the other of the two great groups of powers into which the world is divided. In attempting to formulate the conclusions which followed from our discussions, we too have tried to avoid any exacerbation of the differences between nations which might follow, for example, from emphasis on technical considerations unwelcome to one or other of the two great powers. . . .

"The main work of the meeting was centered round three principal topics: (1) The hazards arising from the use of atomic energy in peace and war; (2) problems of the control of nuclear weapons; and (3) the social responsibility of scientists. Three committees were established to give detailed consideration to these topics. Their reports to the conference are given in the statements appended to this document, but the principal conclusions bearing on the hazards of atomic energy may be briefly summarized as follows:

"Committee I on nuclear hazards, made an independent assessment of the effects of the nuclear tests carried out hitherto. From the details given in the appendix, it may be seen that the hazard, compared with others to which mankind is subject from natural causes, is small. Nevertheless, because of the world-wide distribution of fission products, and the fact that some areas may be subject to effects much above the average, close attention to the dangers should be maintained, especially if tests of bombs which give large radioactive fall-out continue to be made.

"The committee also considered the hazards arising from the peacetime use of industrial atomic power, or the application of radiations in medicine and industry. Although these hazards must be viewed in the light of the great benefits which will flow from such applications, means of greatly reducing the attendant hazards are available and should be widely adopted.

"The above mentioned estimates of the hazards which have arisen from test explosions, permitted a closer examination to be made of the probable consequences of an unrestricted nuclear war. This examination led to the unquestioned conclusion that a general war with nuclear weapons would indeed represent a disaster of unprecedented magnitude. . . .

"It is against the background of the fearful consequences for humanity of a general war with nuclear weapons that the conclusions of Committee II, which considered problems of control, must be viewed. The principal objective of all nations must be the abolition of war. . . .

"For this purpose it is necessary to reduce tension among the nations; to promote mutual understanding among the people; to strive for the ending of the arms race; and to provide an adequate control system so as to give substantial protection, and permit the development of mutual confidence.

"One of the greatest difficulties in international affairs in recent years has sprung from the fact that in a period of delicate strategic balance, even secondary questions acquire strategic significance; in such a situation, they are rarely subject to agreed solutions because any particular solution appears to be to strategic advantage of one rather than another of the powers. We believe that it is unrealistic to depend upon any sudden increase in mutual confidence and that it is more likely to grow from small beginnings. In this situation, even small agreements covering limited fields could be of great importance. . . .

"The conclusions of Committee III on the responsibilities of scientists state our common conviction that we should do all in our power to prevent war and to assist in establishing a permanent and universal peace. This we can do by contributing to the task of public enlightenment concerning the great dilemma of our times; and by serving to the full extent of our opportunities, in the formation of national policies. The Committee gives a statement of beliefs and aspirations suitable for scientists in the modern world.

"Finally, we should like to give expression to the high degree of unanimity we have found among all the members of the Conference on *fundamental aims*. We are all convinced that mankind must abolish war or suffer catastrophe; that the dilemma of opposing power groups and the arms race must be broken; and that the establishment of lasting peace will mark the opening of a new and triumphant epoch for the whole of mankind. We earnestly hope that our conference may make a modest contribution to these great aims."

Underground Nuclear Test

The Nevada Test Organization, of the Atomic Energy Commission and Department of Defense, recently announced that a relatively low yield nuclear device will be detonated underground at the Nevada Test Site in early September. The device will be placed at the end of a multidirectional 2000-foot tunnel into the side of a small mountain near the northwest corner of Nevada Test Site. The detonation chamber is approximately 800 feet below ground surface, a depth sufficient to contain all radioactive material, thus eliminating any airborne radiation and any fallout problem. The experiment is intended to prove this new method of testing as well as to test new instrumentation systems that are necessary.

It has been anticipated that the test will be of interest to seismologists and geophysicists. Information will be released later in the summer to alert seismic stations, not only in the United States, but also in other countries, regarding the date, approximate time, and more precise location.

The general approach to this method of nuclear testing was suggested by Edward Teller of the University of California Radiation Laboratory, in association with David Griggs of the University of California, Los Angeles. Calculations of required depth of burial to contain the detonation were confirmed by high-explosive detonations at Nevada Test Site. These initial tests, one of them involving 50 tons of high explosives, were conducted by the U.S. Geological Survey.

Educational TV and Science

The Educational Television and Radio Center, Ann Arbor, Mich., which provides a national film program service for the 23 noncommercial educational television stations affiliated with it, is developing a number of programs in science. The center supplies its stations with 15 programs per week. Some of those that are in production follow. While these programs are developed primarily for use over the noncommercial educational television stations, they will be made available for 16-mm projection in classrooms through the center's N.E.T. Film Service, Audio Visual Center, University of Indiana, Bloomington, late in 1958.

"The Secret of Flight," a series of 13 programs, will deal with the basic problems of flight, explained by experiments and discussions. Purely scientific language is avoided. A smoke tunnel is used in conjunction with scale models and flying models. The series features Alexander M. Lippisch, designer of the delta-wing type of aircraft, and the aerodyne, a new concept in flight. Lippisch is director of the aeronautical research laboratory of Collins Radio Company in Cedar Rapids, Ia. The series is being produced by the State University of Iowa under contract with the center.

A noncommercial community station

in San Francisco, Calif., KQED, is producing a two-program series called "Tempest in a Test Tube," featuring Harry Sello, research chemist at the Shell Development Company. The purpose of the series is to awaken an interest in chemistry and the allied sciences on the part of the teen-ager—particularly the junior-high-school student. The format includes many lively and colorful experiments with an informal explanation of the principles involved. Continuity and experiments are developed by a committee from the American Chemical Society.

Medical problems affecting future space travel are explored in a series of 13 half-hour programs called "Doctors in Space," which is to be filmed in part at the U.S. Air Force School of Space Medicine, Randolph Air Force Base, Tex. The series will feature Hubertus Strughold, chief of the school, and will use film now available at the school as well as specially prepared shots. Station KUHT in Houston, center affiliate, is producing the series under contract with the center.

"The World and Physics" is a series of 13 45-minute programs that features Edward Teller, and five high-school science students. Designed to stimulate curiosity about and increase knowledge of science among high-school students, the series will cover fundamental concepts in the physical sciences and will emphasize ideas rather than demonstrations and experiments. Each program will begin with an elementary description of the subject and will gradually develop to a point when the ideas involved will challenge the imagination of the participating students and of the viewers. The series is another being produced for the center by station KQED.

A series of 13 half-hour programs, "Nuclear Energy—Key to Tomorrow," will explain the fundamental principles of atomic energy and outline its peacetime applications. Being produced under contract with the center and its affiliate, station WQED in Pittsburgh, the series will draw on the resources of the Westinghouse Atomic Research Division, the Carnegie Institute of Technology, the University of Pittsburgh, and the Atomic Energy Commission. Featured participants will be representatives of the Westinghouse Atomic Research Division.

"Of Science and Scientists," with Philippe Le Corbeiller of Harvard University acting as coordinator and host, is a series of programs organized by Harvard and produced by educational station WGBH-TV in Boston. The series will provide an introduction to the scope and methods of the physical sciences. It will illustrate how the scientist thinks and works and will tell what he can and cannot do. Each program will focus on a single idea and will involve experimental demonstrations and graphic illustrations from which discussion by one or more participants will develop. Some titles from the 23-program series are "Nature versus the Laboratory," "Science and Common Sense," "Are Scientists Dogmatic?," "Are Atoms Real?," and "Why Science Works." There are 23 programs in the series, each one-half hour in length.

Whitney Biological Fellowships

The Helen Hay Whitney Foundation, New York, has announced that fellowships are available to people in the United States or abroad, up to the age of 35, holding the degree of M.D., Ph.D., or equivalent, who are seriously considering a career in biological or medical research, preferably related to connective tissue and its diseases. Stipends will be arranged to meet the needs of the fellow. Applications, to be submitted *before 15 Sept.*, should be requested from the Executive Secretary, Helen Hay Whitney Foundation, 525 E. 68 St., New York 21, N.Y.

The foundation was established in 1947 to support research in rheumatic fever. Its activities have recently expanded to include the study of connective tissue and its diseases.

Philosophical Society Awards

The American Philosophical Society invites applications for grants in support of basic research, in accordance with the following general principles. Grants may be made for research in any field of scholarship and may include funds to cover travel and other expenses in connection with the collection of material for research. Grants are not made toward the payment of salaries of members of the staff of an educational or scientific institution, or for fellowships or scholarships, or for expenses in connection with the preparation of a doctoral dissertation. Support of a long-continuing project is not undertaken except in its initial stage. Applications should be typewritten on forms which may be obtained by addressing the Executive Officer, American Philosophical Society, 104 S. Fifth St., Philadelphia 6, Pa.

Corporate Giving and Public Health

Measured in dollars, the total effort of the American people to raise and maintain the national standard of health reaches the annual amount of $13 billion, according to the National Better Business Bureau, which has recently released a survey report entitled *Corporate Contributions to National Health Agencies.* The $13 billion covers a great variety of health activities—hospital care, research, preventive medicine, sanitation, food and drug regulation, and public information. However, the national health agencies, including the 26 which cooperated in the survey, deal with these problems selectively—that is, each one confines its interest to the field of a single disease.

The report showed a great diversification of reasons for giving to national health agencies, although nearly all national business firms are supporting them, both through direct contributions and through United Funds or Community Chests. It further showed that the number of national health agencies to which the average company contributes has doubled during the past 5 years. Among the reasons for contributing to national health agencies, 41 of the 158 corporations surveyed gave "effect of disease upon the economy."

Cardiovascular Disease Abstracts

Publication of the first issue of *Cardiovascular Diseases,* an abstract periodical, has been announced by the U.S. Public Health Service and the Excerpta Medica Foundation. For this purpose, a grant of $28,750 for the first year was made to the foundation by the National Heart Institute of the Public Health Service, on recommendation of the National Advisory Heart Council. Similar grants are contemplated for each of four additional years.

The publication's advisory board will have 40 members, nine from the United States. About 7000 abstracters throughout the world will contribute capsule versions of heart literature from approximately 1800 selected journals.

Metropolitan's Death Statistics

Diseases of the heart, arteries, and kidneys accounted for 57 percent of the $429 million paid out by the Metropolitan Life Insurance Company in death claims last year. Cancer ranked second as a cause of death-claim payments. Together, these causes of death accounted for more than $3 out of every $4 paid in claims to beneficiaries.

The company's 1956 death-claim payments were the highest ever, rising $33,348,000—or 8.4 percent—over the previous high total in 1955, and two and a half times the amount paid 20 years ago. The uninterrupted rise in death claims in a period of decreasing mortality, the company's statisticians point out, reflects both the growth in number of policyholders and the larger amount of life insurance owned per policyholder.

The rise in the proportion of disbursements for the degenerative diseases of

later life is, in part, a consequence of the long-term decrease in mortality from the infectious diseases. For example, tuberculosis in 1956 accounted for only one-third of the payments made for this cause in 1936, while the proportion of disbursements for pneumonia and influenza declined from 8.0 percent to 1.5 percent in the same period.

The external causes of death accounted for somewhat more than one-tenth of the claim payments last year. About $34,330,000 was paid on fatal accidents, with more than half the payments on deaths resulting from motor vehicle accidents.

More than $280 million, or two-thirds of the total death claim payments last year, was for policyholders who died before reaching age 65. About $55,760,000 was disbursed on insured persons who died in the ages from 25 through 44, and more than $216 million on those who were between 45 and 65 years of age when they died.

Public Health Grants

Grants and awards totaling $1,020,143 for the training of public-health specialists have been announced by the U.S. Public Health Service. The 230 recipients included physicians, engineers, health educators, laboratory workers, dentists, and members of other health professions. These people will enter colleges and universities throughout the nation this fall for a year of training in the public-health aspects of their professions. Grants amounting to $919,878 also were made to 44 colleges and universities offering public-health nursing courses and to 11 schools of public health to assist in the training of students whom the schools select.

This is the second year that public-health training funds have been available from the Federal Government. Last year, under a $7-million appropriation, the traineeship grants and awards financed the training of 364 public health workers. The purpose of the program is to help relieve the acute personnel shortages in state and local health agencies. In selecting trainees, consideration is given to the professional categories in which personnel shortages are most acute, the age of the candidates, their previous training and experience, and other factors that will increase the supply of young, well-trained workers.

Rare Chemicals

The following chemicals are wanted by the Registry of Rare Chemicals, Armour Research Foundation of Illinois Institute of Technology, 35 W. 33 St., Chicago 16, Ill.: zirconium tetraisopropoxide; 3,4-dimethylbenzoic acid; 2,3-diaminobenzoic acid; lead tetrachloride; spiro (3.3) heptane; 2,4,5-tris(p-chlorophenyl)imidazole; 2-heptylnonanoic acid; 1,2-methylenedioxybenzene; acetone azine; 4,4″-diamino-p-terphenyl; 4-methoxy-phloretic acid; menthofurane; 1,2,3,-4,5,6,7,8-octahydroanthracene; phenyldichloroarsine; 2-methoxybenzophenone; 3,4-methylenedioxyphenethylamine (homopiperonylamine); p-hydroxycinnamic acid; n-decyl benzene; triacontane; umbellulone.

Pre-College Science Center

Through the generosity of the Dorr Foundation and the Loomis Institute, the Pre-College Science Center has been established to offer boys of high-school age, who are interested in possible careers in the physical sciences, an opportunity to pursue a special summer program. This program allows the talented student to follow his natural interest and to extend his competence in a specific area of the physical sciences and related mathematics.

There are 24 boys in the first class, each one carefully selected from Connecticut public, private, and parochial schools on the basis of exceptional ability in science. The students and resident staff of the center are using the living, recreational, and laboratory facilities of the Chaffee and Loomis Schools, adjacent to each other, in Windsor, Conn.

The center's strategic position in Hartford County near applied laboratory and research facilities in a variety of scientific fields has made it possible to provide a diversified group of engineering advisers, to one of whom each student is specifically assigned for a section of the program.

The study program is flexible and is adjusted to the aptitudes, interests, and backgrounds of the students selected. The course of study is not intended as an intensive program or as an accelerated course but rather as an opportunity for a selected group of boys with unusual ability in science and mathematics to live and work together happily while pursuing their common and individual interests.

There is no tuition charge. A single fee of $175 partially defrays the cost of board, room, and laundry. A few scholarships are available for students in the amount of this fee in the case of genuine financial need. Since the cost to the sponsors averages about $1200 per student, the fee is a small part of this total.

Because the size of the group invited to attend the center is limited, students are selected on a competitive basis from a large number of applicants. The students accepted must have completed at least the sophomore year in high school; however, an exceptionally well qualified student who has completed the freshman year might be considered. Each year requests for application blanks must be made by 15 Apr. and completed forms be filed within a month.

Proposed Legislation

Of the many bills introduced in Congress, some have a special relevance to science and education. A list of such bills introduced recently follows:

HR 8386. Lessen nation's dependence on foreign sources of supply for tungsten in times of emergency. Baring (D Nev.) House Interior and Insular Affairs.

HR 8328. Amend Internal Revenue Code of 1954 to impose import taxes on lead and zinc. Baring (D Nev.) House Ways and Means.

S 2447. Authorize and direct Secretary of Interior to undertake continuing studies of effects of insecticides, herbicides, and fungicides upon fish and wildlife. Magnuson (D Wash.) Senate Interstate and Foreign Commerce.

HR 8461. Amend Atomic Energy Act of 1954 to provide for appointment of representatives of U.S. in organs of International Atomic Energy Agency; make provisions re participation of U.S. in that Agency. Cole (R N.Y.) Joint Atomic Energy.

News Briefs

Electric power was produced for the first time on 12 July by heat from the Sodium Reactor Experiment (SRE) during tests of the reactor and auxiliary components at a plant in the Santa Susana Mountains about 30 miles northwest of Los Angeles, Calif. The SRE was designed and built for the Atomic Energy Commission by Atomics International.

* * *

The first motion picture of Project Vanguard, the launching and tracking of the earth satellite, has been distributed to 225 television stations in 12 countries, as well as to motion picture theaters, by the International Business Machines Corporation. Produced by Transfilm, the 4-minute animated film is titled "A Moon Is Born" and is being shown in both color and black and white.

* * *

The Geological Survey of India has located a rich mineral area in the Nagpur district in the state of Bombay. The region contains deposits of chromite, copper, gold, iron, and antimony.

* * *

West German natural scientists will shortly begin a geologic investigation of the bed of the North Sea for oil and

other valuable deposits. The 5-year investigation will be carried out chiefly by the surveying ship *Gauss* of the Hydrographical Institute in Hamburg. A number of other West German research institutes will participate in the project.

* * *

A program to improve science teaching in Burma has been aided by the Asia Foundation. The United Nations Educational, Scientific, and Cultural Organization reports that the foundation has donated radio transmitters and receivers, model telephones, model steam engines, instruments to measure humidity, astronomical charts, and other scientific equipment to three science clubs in Burma. The clubs were organized by the Burmese Government with the aid of the United Nations to stimulate out-of-school interest in scientific subjects.

August Scientific Monthly

Articles appearing in the August issue of *The Scientific Monthly* are "Origin of the amniote egg," A. S. Romer; "World affairs, languages, and children," K. Mildenberger; "Origin and use of the English peat fens," K. Thompson; "Social responsibility of the physician," H. J. Geiger; "Minimum earth satellites as 'storm patrol,'" S. F. Singer. Three articles based on papers presented at a symposium on American foreign aid are included: "Purposes of international aid programs," H. vanB. Cleveland; "Foreign aid and the theory of economic development," R. Nurske; "Future of American foreign aid," M. F. Millikan. Thirteen books are reviewed.

Scientists in the News

Two astronomers have retired from the staff of the Mount Wilson and Palomar Observatories: MILTON L. HUMASON, whose observations have provided most of the evidence supporting the theory of the expanding universe, and SETH B. NICHOLSON, specialist in solar phenomena and discoverer of four of Jupiter's satellites.

Humason joined the Mount Wilson Observatory in 1917, first as janitor and then as night assistant. In the latter capacity he displayed such skill as an observer that he was made a member of the staff of investigators in 1922. He first assisted in a survey of early-type stars with bright hydrogen lines, later in a study of stellar magnitudes and parallaxes.

In the course of this work, Humason developed an unusual proficiency in the photography of spectra of very faint objects. Following the discovery by the late Edwin Hubble in the 1920's of the major role played by the extragalactic nebulae in the structure of the universe, Humason turned to the study of these objects and soon accumulated spectra of a substantial number of galaxies spread over a wide range of distances. It was a study of the relationship between the velocities as measured on these spectrograms and the distances of these galaxies that led Hubble to the concept of the expanding universe. For the following quarter-century Humason devoted most of his attention to this problem.

The introduction of extremely fast photographic plates, the development of new and very rapid spectrographs, and the completion of the 200-inch Hale telescope enabled Humason to push his observations to fainter and fainter and, therefore, more and more distant galaxies. These techniques now permit photographing the spectra of galaxies far too faint to be seen visually with the telescope used to collect the light. Humason therefore had to develop elaborate offset procedures that insure locating invisible images accurately on the slit of the spectrograph and holding them there during long exposures. His studies culminated in the publication in 1936, in collaboration with N. Mayall of the Lick Observatory and Allan Sandage of the Mount Wilson and Palomar Observatories, of the velocities of more than 900 galaxies. Some of these velocities are as high as one-fifth of the velocity of light.

In 1948, Humason was appointed secretary of the observatories, in which capacity he handled the correspondence and public relations, as well as many other administrative problems, of the observatories. A native of Dodge Center, Minn., Humason received his Ph.D. degree honoris causa, from Lund University, Sweden.

Nicholson joined the staff of the Mount Wilson Observatory in 1915. During his first few years he investigated the orbits of several of Jupiter's satellites, the ninth of which he had discovered at Lick Observatory in 1914. In collaboration with Edison Pettit, he developed a very sensitive vacuum thermocouple. This they used to measure the total radiation and surface temperature of stars, the planets, and the moon. Studies of the rates of cooling of the moon's surface during an eclipse gave a measure of the thermal conductivity of the surface rocks and provided information on their physical characteristics. In the late 1930's and again in the early 1950's, Nicholson returned to the observation of Jupiter's satellites and discovered the tenth, eleventh, and twelfth of these objects and determined the positions necessary to fix their orbits.

Throughout Nicholson's 42 years at the observatories, a large part of his efforts have been devoted to solar observations. He has developed a detailed knowledge of the complex phenomena of the sun's visible surface. He has supervised the systematic collection of data on sunspots, including the polarity and strength of their magnetic fields. In collaboration with Oliver Wulf of the California Institute of Technology and the U.S. Weather Bureau, he has made detailed investigations of the correlation between solar and terrestrial phenomena.

Nicholson received his B.S. degree in 1912 at Drake University and his Ph.D. degree in 1915 at the University of California. He is a member of the National Academy of Sciences.

LLOYD C. MITCHELL, research chemist for the U.S. Food and Drug Administration, Washington, D.C., is to receive the annual Harvey W. Wiley award of the Association of Official Agricultural Chemists. Mitchell is the first winner of the award, which was established last year to honor the father of the original Pure Food and Drug Law. The $500 award goes to a scientist who has made an outstanding contribution to the development of methods for the analysis of foods, drugs, cosmetics, feeds, fertilizers, pesticides, and soils.

A food chemist from the beginning of his career in 1909, Mitchell has developed many methods of analysis for spices, cereals, dairy products, and eggs. Especially well known are his studies published in 1932 and 1933 on the composition of shell eggs and commercial egg products.

This year's honorary degree recipients include the following:

HERBERT M. EVANS, emeritus professor of anatomy at the University of California, from Johns Hopkins University.

BENTLEY GLASS, professor of biology at Johns Hopkins University, from Washington College.

JOSEPH R. NELLER, soil chemist at the University of Florida Agricultural Experiment School, from Macalester College.

FRANCO RASETTI, professor of physics in John Hopkins University, from the University of Glasgow, Scotland.

TRACY SONNEBORN, professor of Zoology at Indiana University, from Johns Hopkins University.

CARL P. SWANSON, professor of botany at Johns Hopkins University, from the University of Massachusetts.

JOHN H. WILSON, formerly head of the editorial branch of the Technical Information Department at the China Lake (Calif.) Naval Ordnance Test Station, has been appointed technical writer and editor for the Atlantic Research Corporation, Alexandria, Va.

FRANK PRESS, since 1955 professor of geophysics at California Institute of Technology, has been named director of the Seismological Laboratory. He succeeds BENO GUTENBERG, who is retiring to half-time status after 27 years at the institute and 10 years as director of the laboratory.

Four clinical professors in the Faculty of Medicine, Harvard University, retired on 30 June to become emeritus clinical professors: THOMAS R. GOETHALS, obstetrics; CHESTER M. JONES, medicine; THOMAS H. LANMAN, surgery; and SAMUEL A. LEVINE, medicine.

Goethals, a specialist in obstetrical problems concerned with breech births, received the A.B. degree in 1912 and the M.D. degree in 1916 from Harvard. He joined the staff of the Harvard Medical School in 1920 as alumni assistant in obstetrics and was named clinical professor of obstetrics in 1930. For 20 years (1930–50) he was the senior obstetrician to the Massachusetts General Hospital and is now a member of the Board of Consultation there. Since 1946 he has been senior obstetrician at the Boston Lying-In Hospital.

Jones is a specialist in diseases of the stomach and intestinal tract. He is responsible for the revision of the postgraduate course in internal medicine offered at the Massachusetts General Hospital. He received the A.B. degree in 1913 from Williams College, the M.D. degree in 1919 from Harvard, and the S.D. degree (honorary) in 1942 from Williams. He has been a member of the Harvard Medical School staff since he was named assistant in medicine in 1921 and has been clinical professor of medicine since 1940. Between 1928 and 1954, Jones was physician at the Massachusetts General Hospital, where for the past 3 years he has been consulting visiting physician and is now a member of the Board of Consultation. He also served as associate professor of medicine, Vanderbilt University, (1940–41); as consultant in medicine to the Surgeon General of the United States (1944–48), and as vice chairman of a medical mission to Austria in 1947 and to Greece and Italy in 1948. In 1956 he received the Rogerson cup, which is awarded annually to the outstanding alumnus of Williams College. In 1956 he was chosen as the Shattuck lecturer by the Massachusetts Medical Society.

Lanman has been actively engaged in the teaching of surgery to both undergraduate and postgraduate students at the Harvard Medical School since 1928. At the Children's Hospital he developed methods of dealing with urological disorders of infancy and childhood that have become standard procedures throughout the world. He is also a pioneer in the surgical treatment of pulmonary disorders in infants and young children. In 1954 he became the first recipient of the William E. Ladd medal of the American Pediatric Society for major contributions to pediatric surgery. Lanman received the A.B. degree in 1912 and the M.D. degree in 1916 from Harvard. He joined the staff of the Harvard Medical School as an assistant in genitourinary surgery in 1920 and became clinical professor of surgery in 1947. He is consultant in surgery at the Peter Bent Brigham Hospital and visiting surgeon at the Children's Hospital.

Levine is a specialist in diseases of the heart and was the second American physician (the first was James B. Herrick of Chicago) to diagnose and describe coronary thrombosis. He was born in Poland, and his parents emigrated to the United States when he was 3. A former Boston newsboy, Levine was the second recipient of a Harvard scholarship established by the Newsboys' Union of Boston. He received the A.B. degree from Harvard in 1911 and the M.D. degree in 1914. He joined the staff of the Harvard Medical School as an assistant in medicine in 1919 and was named clinical professor of medicine in 1948. He is a member of the staffs of the Peter Bent Brigham, Newton–Wellesley, and Beth Israel hospitals. In 1954 the late Charles E. Merrill, then senior partner in the New York investment firm of Merrill Lynch, Pierce, Fenner and Beane, established the Samuel A. Levine professorship of medicine in Harvard Medical School, honoring his friend and physician. Levine's many honors include the Scientific Award (1940) of Phi Lambda Kappa medical fraternity. In 1948 he was selected to deliver the St. Cyres lectures in London.

JAMES B. CULBERTSON, head of the department of chemistry at Cornell College, has won the 1957 Iowa medal of the American Chemical Society's Iowa Section. The medal will be presented at a banquet of the section in the Iowa Memorial Union on 25 Oct. Culbertson, who has carried out important studies on the chemistry of acetylene, will be cited for his "excellence in teaching with maintenance of interest in research."

DERRICK T. VAIL, chairman of the department of ophthalmology in the Northwestern University Medical School, was honored recently by members of the Oxford Ophthalmological Congress at Oxford, England, for his outstanding contributions to ophthalmology. A worldwide organization, the Oxford Ophthalmological Congress was founded in 1909 by Robert Doyne, a British ophthalmologist. Each year an international council invites an outstanding eye surgeon to deliver the Doyne memorial lecture and to receive the Doyne medal. Vail is the second American in the history of the congress to be so honored.

WILLIAM C. PADDOCK, professor of plant pathology at Iowa State College, has been named director of the Pan American School of Agriculture at Zamorano, Honduras. He succeeds the original director of the school, WILSON POPENOE, who has been named director emeritus.

Recent Deaths

HARRY C. W. DE BRUN, Saranac Lake, N.Y.; 67; professor of surgery at the New York Polyclinic Hospital and Medical School; retired surgeon for the New York City Police Department; 16 July.

HENRY JAMES, New York, N.Y.; 76; cardiologist, senior attending physician and assistant professor of clinical medicine at Bellevue Hospital, New York, N.Y.; 14 July.

SOPHIA V. KEIL, Long Island, N.Y.; 77; retired nurse in the physical therapy department of St. Luke's Hospital, New York; accompanied Sir Wilfred Grenfell, British medical missionary, to Labrador; 6 July.

SIMON S. LEOPOLD, Philadelphia, Pa.; 65; emeritus professor of clinical medicine at the University of Pennsylvania's Medical School and Graduate School of Medicine, author of a standard textbook on diagnosis; 13 July.

FREDERICK J. LYNCH, Boston, Mass.; 67; formerly department chairman and professor of obstetrics at Tufts College Medical School and assistant in gynecology at the Harvard Medical School; a former vice president of the American Medical Association; 15 July.

JAMES B. NEALEY, Columbia, S.C.; 67; retired mining engineer, formerly mines and metals editor of the *New York Commercial*; 10 July.

LOUIS E. SCHMIDT, Chicago, Ill.; 88; urologist and early leader in the drive against venereal disease, formerly head of Northwestern University's department of urology; established the first genitourinary clinic west of the Alleghenies, fathered laws for premarital and prenatal tests for syphilis; 12 July.

MARTIN A. SPIELMAN, Chicago, Ill.; 51; research chemist and director of research evaluation at Abbott Laboratories; noted particularly for his work on antiepileptic drugs; formerly assistant professor of chemistry at the University of Wisconsin; 11 July.

FRED TONNEY, Chicago, Ill.; 76; public health officer who served in Ohio, Texas, Michigan, and Illinois; a member of the Chicago Board of Health for 30 years; 13 July.

Reports

Strontium-90 and Skeletal Formation

An important question involved in evaluation of hazards of radioactive fallout from nuclear weapons testing is the relationship between observed strontium-90 levels in contemporary human bones of various ages and the maximum level which would be reached if the skeleton were formed in equilibrium with the primary sources of strontium and calcium. Since fallout of strontium-90 has begun only recently, adult bone formed before the first nuclear tests will contain only that amount of strontium which can enter the bone through chemical exchange and bone remodeling. Bones of children will contain varying quantities of strontium-90, depending on the amount of new bone growth (which varies with age) plus bone remodeling and exchange during the period over which sources of skeletal calcium were contaminated.

From a knowledge of the amount of bone remodeling plus exchange and the rates of skeletal growth and strontium-90 increase in the biosphere, it is possible to compute the fraction of equilibrium strontium levels to be expected in skeletons of growing children as a result of direct incorporation during the period of environmental contamination. Adding the contribution of bone remodeling and exchange to the contribution of new bone growth will give a total skeletal burden in terms of the equilibrium level.

Data on yearly accretion of skeletal calcium for males were taken from Mitchell *et al.* (*1*) and are given in Table 1. Data presented by Libby (*2*) indicate that environmental strontium-90 contamination essentially doubled every year from 1952 through the fall of 1956.

It is assumed that each yearly increment of skeletal growth will contain strontium-90 at a concentration corresponding to the strontium-90 build-up in the biosphere for that year. For a first approximation, the skeleton is regarded as a unit, and the strontium-90 burden is averaged over the entire skeleton. As better data become available, it will be profitable to consider the individual bones separately, both in terms of their strontium-90 burden and their radiosensitivity.

The calculated apparent fraction of equilibrium strontium-90/calcium ratio as a function of age, based on skeletal growth rate alone and a yearly doubling time of the strontium-90 level, is shown by the solid curve of Fig. 1. The method of calculation is best explained by an example using data from Table 1. For an 8-year old skeleton in 1956, the last 33 g of calcium contain an equilibrium concentration C of strontium, and thus a total amount of strontium equal to $33C$. The previous year's deposition of 26 g would have been formed with a concentration $C/2$ of strontium and would contribute $13C$. The fifth and fourth years' growth would incorporate 20 $C/4$ and 18 $C/8$ units of strontium, respectively. The total strontium in the skeleton at age 8 is, therefore, $(33 + 13 + 5 + 2.5)C$, or $53C$. (A 4-year cut-off is used since large-scale testing began in 1952. Actually, the series is converging so rapidly that the cut-off has little effect.) If the entire skeleton had been in equilibrium with the strontium-90 level of the environment in the eighth year, it would have contained $297C$ units of strontium-90. The fraction of equilibrium is, therefore, $53C/297C$, or 0.18.

Kulp *et al.* (*3*) recently reported strontium-90 analyses of 484 bone samples from persons of all ages collected during late 1955 and the spring of 1956 at 17 stations in a world-wide sampling network. The average strontium-90 value for all age groups was 0.12 μμc/g of calcium, and bones of young children showed strontium-90 values 3 to 4 times the average for all ages. The average strontium-90 content of 64 bone samples in the 0- to 4-year age group was reported as 0.31 μμc/g of calcium, after results from rib samples had been divided by 2 and those from vertebrae had been divided by 4 to obtain an average for the total skeleton. This adjustment was predicated on strontium-85 distribution studies in adult cancer patients who had been given a single injection 3 hours to 125 days before death, and resulted in the lowering of average values by approximately a factor of 2.

Data on stable strontium content (*4*, *5*) of various human bones suggest that the afore-mentioned adjustment to obtain a skeletal average may not be valid for children in whom a major portion of the skeletal calcium was laid down during the period of strontium-90 environmental contamination. In the case of adults, however (in whom the majority of strontium-90 was laid down over a period relatively short compared with the age of the individual), the adjustment might be justified. We have chosen, therefore, to use Kulp's unadjusted values for subjects under 20 years of age and to accept his adjusted data for adults. These data, normalized to the 0- to 4-year age group as representing 59 percent of equilibrium strontium-90 concentration, are shown by the points in Fig. 1.

These data show that, at age 24 (4 years beyond the age at which skeletal growth stops) about 10 percent of the skeletal calcium was involved in bone remodeling plus exchange during the

Table 1. Yearly accretion of skeletal calcium in males.

Age (yr)	Calcium (g)		Fraction of equilibrium Sr^{90}/Ca
	In total skeleton*	Increase per year	
0	28		0.50†
1	100	72	0.79
2	147	47	0.59
3	179	32	0.42
4	201	22	0.29
5	219	18	0.20
6	239	20	0.16
7	264	26	0.16
8	297	33	0.18
9	341	44	0.20
10	396	55	0.22
11	463	67	0.23
12	539	73	0.24
13	624	85	0.23
14	715	91	0.22
15	806	91	0.21
16	894	88	0.19
17	973	79	0.16
18	1035	62	0.13
19	1073	38	0.09
20	1078	5	0.045
21	1078	0	0.019
22	1078	0	0.006
23	1078	0	0.001
24	1078	0	0.000

* From Mitchell *et al.* (*1*). † Assuming 50 percent fetal protection (6).

All technical papers and comments on them are published in this section. Manuscripts should be typed double-spaced and be submitted in duplicate. In length, they should be limited to the equivalent of 1200 words; this includes the space occupied by illustrative or tabular material, references and notes, and the author(s)' name(s) and affiliation(s). Illustrative material should be limited to one table *or* one figure. All explanatory notes, including acknowledgments and authorization for publication, and literature references are to be numbered consecutively, keyed into the text proper, and placed at the end of the article under the heading "References and Notes." For fuller details see "Suggestions to Contributors" in *Science* 125, 16 (4 Jan. 1957).

period of environmental contamination. The data further suggest that the amount of calcium involved decreases with age, which is in keeping qualitatively with classic concepts of bone physiology. If a similar fraction of the skeletal calcium of growing subjects is involved in exchange plus remodeling, then the strontium-90 levels in children would be proportionally higher than the curve based on skeletal calcium accretion alone. This indeed appears to be the case and indicates that the major factors have been considered in constructing the model.

If the fraction of remodeling and exchange for children's bones is similar to that observed for adults, then the accretion curve below age 20 should be raised proportionately, to give the over-all apparent fraction of equilibrium strontium-90/calcium ratio as a function of age (dashed line, Fig. 1). This curve permits the use of adequate bone data from any age group to predict the average maximum equilibrium strontium-90 bone level and indicates an average maximum equilibrium level of 0.9 μμc/g of calcium at the end of 1955.

The strontium-90 content of skeletons of stillborns (*2*) during 1955 averaged about 0.5 μμc/g of calcium, which gives an average maximum equilibrium level of 1.0 when the placental discrimination factor of 0.5 (*6*) is considered. Bryant *et al.* (*7*) in England reported analyses of 28 bone samples from subjects of all ages collected about January 1956. Eight samples from persons ranging from 3 months to 3½ years old (average 1⅓ years) averaged 0.9 μμc of strontium-90 per gram of calcium, and 11 subjects ranging from 20 to 65 years of age (average 36 years) averaged 0.07 μμc of strontium-90 per gram of calcium, after all rib results had been divided by 2. The predicted average maximum strontium-90 equilibrium level about January 1956, based on these age groups, is 1.0 and 0.9 μμc/g of calcium, respectively.

Since the strontium-90 environmental contamination level continued to rise during 1956, the predicted average maximum strontium-90 equilibrium level of new bone as of the first part of 1957 is about 1.8 μμc/g of calcium. The frequency distribution patterns have been reported for strontium-90 (*8*), stable strontium (*5*), natural radium (*9*), and cesium-137 (*10*). All these nuclides show essentially normal distributions with standard deviations of about 35 percent, which suggests that the range ($\pm 3\sigma$) of strontium-90 equilibrium levels as of the first part of 1957 for the world population will be between about 0.3 and 4 μμc/g of calcium.

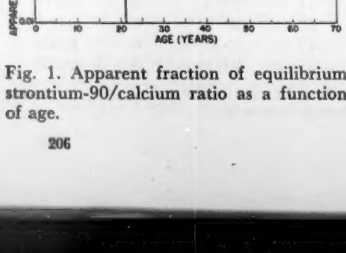

Fig. 1. Apparent fraction of equilibrium strontium-90/calcium ratio as a function of age.

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27 May 1957

Chemically Induced Cell Proliferation and Its Inhibition by a Naturally Occurring Antiauxin

There are several types of cellular abnormality which can be induced in plants by a properly chosen kind or concentration of chemicals, including animal carcinogens. Among these are (i) proliferation of mature cells, as when callus tissue forms from pith or cortical cells after wounding (Fig. 1); (ii) unorganized division of cells in meristematic regions, as with 2,4-dichlorophenoxyacetic acid (*1*, Figs. 4–7); (iii) hypertrophy of cells in certain areas; (iv) inhibition of apical dominance (Fig. 2); and (v) cell elongation, producing epinasty (*2*, Figs 1–3). Chemical stimulation can also produce hyponasty, as with maleic hydrazide and taller plants with gibberellic acid (*3*). These various types of cell abnormality and the resulting morphologic irregularities can be inhibited by the use of the naturally occurring antiauxin previously reported (*1, 2, 4*).

The callus type of proliferation was used as the assay technique in the present study (*5*). Callus forms by rapid division of mature pith and cortical cells. A slit about ¾ inch long was made in the third to fourth internodes from the tips of cocklebur plants (*Xanthium* sp. native to western Wisconsin) having several mature leaves. Moist spaghnum moss was maintained about the slit stems to provide a humid environment favorable for callus development.

The poor solubility of antiauxin in solvents suitable for application to plants led to the practice of placing crystals in the slits when its effect on callus production was being tested. Presumably, antiauxin is soluble in the lipoidal phase of the plant and therefore would be transported through this medium.

This practice of implanting crystals was continued when chemicals were tested for their tumor-producing potentiality. Approximately 0.5 mg or less of the crystals was used, and, in the case of liquids, one drop.

A record of the presence and extent of formation of callus was made at 5 to 7 days after treatment. The tumorous tissue deteriorates soon after this time because it is isolated from the plant by the rapidly forming wound periderm. It is the formation of a "cork cambium" under a wound that produces the short life of callus tissue, rather than any inability of the proliferating tissue to continue to regenerate (as in neoplasia of animal tissues).

More callus tissue than normal was formed when the following chemicals were applied to the plants (Fig. 1): acetates of ammonia, barium, calcium, copper, iron, lead, magnesium, mercury, potassium, silver, sodium and zinc; 1-percent acetic acid; acetone; adenine sulfate; adipic acid; androstenediol; androstenedione; arginine monohydrochloride; benzanthracene; benzene (axillary bud injury and callus formation in the leaf axis); 1,2-benzopyrene; 3,4,-benzopyrene; beryllium; beta alanine; betaine hydrochloride; carboxymethylcellulose; cephalin; chloromelamine; chloropromazine hydrochloride; cholesterol; cholic acid; choline; copper tartrate; croton oil; cyclopentanone; deoxycholic acid; dibenzanthracine; diethylstilbestrol; 4,4-dihydroxydiphenyl; diosgenin acetate; disodium malonic acid; estradiol; ethyl carbamate; ethylenedinitrilotetraacetic acid; folic acid; guanine hydrochloride; hecogenin; hexamethylenediamine; histamine; histidine dihydrochloride; hydrocortisone acetate; 3-hydroxy-2-butanone; 5-hydroxyindoleacetic acid; 8-hydroxyquinoline; iron tartrate; isopropyl maleimide; kynurenine; 1-kynurenine sulfate; malic acid; melamine; methylcholanthrene; morpholine; naphthyl maleimide; oleic acid; oxapentamethylenediethylenethiophosphoramide (OPSPA); pentadecylcatochol; quinal-

dic acid; sarsasapogenin; serotonin creatinine sulfate; serotonin hydrochloride; sesame oil; smilagenin and its acetate; sodium oleate; sodium tartrate; sodium trichloroacetic acid; stigmasterol acetate; tartaric acid; testosterone; testosterone propionate; thioacetamide; thiourea; tobacco tar extract "C"; trichloroacetic acid; trimethanolamine; triethylenemelamine; uracil; uric acid; vinyl cyclohexane; and xanthine.

It should be assumed that more extensive tests with different dosages of the chemicals on trial would result in reclassifications of the activity of some of them.

Antiauxin inhibited the stimulatory effect of nearly all of the afore-mentioned materials. There was limited inhibition in the cases of adipic, deoxycholic, folic, malic, and oleic acids.

Following are chemicals which were found neither to increase nor to reduce callus tissue formation beyond the normal at the dosages used and under the experimental conditions of the trials: acetylaminofluorene; acetylcholine chloride; *n*-acetyl-1-kynurenine; acetylpodophyllotoxin pyridinium chloride; adenosine triphosphate; *o*-aminohippuric acid; ammonium carbonate, nitrate, oxalate, phosphate, and tartrate; androsterone; anthracene; anthranilic acid; antimycin A; antistine; ascorbic acid; azaguanine; benzoylcarbinol; caffeine; calciferol; 3-chloroisopropyl carbamate; chrysene; citric acid; corn oil; cortisone acetate; coumarin; deoxycortisone and its acetate; diamino purine; digitonin; dimethylazoaniline; dimethylnaphthylazoaniline; diosgenin benzoate; disodium malonic acid; ethyl acetate; histone; hydrocortisone; 3-hydroxy-*dl*-kynurenine; 8-hydroxyquinaldic acid; 5-hydroxytryptamine; kynurenic acid; lecithin; 6-mercaptopurine; *dl*-methionine; *n*-methyl-2-pyridone-5-carboxamide; mineral oil; myristil choline chloride; naphthyl acetamide; niacin; nicotine; nicotinic acid; nortestosterone; olive oil; phenanthrene; phenothiazine; phytol; piperazine estrone sulfate; podophyllin; podophyllic acid sodium salt; polyvinylpyrrolidine; Reichstein's substance "S" and its acetate; riboflavin; saponin; *dl*-serine; sitosterol; sphingomyelin; stearone; succinic dehydrogenase; thiamine hydrochloride; thiobromine; thiophyllin; thymidine; tolylazotoluidine; triphenylmethane; l-tryptophan; urea; and xanthuronic acid-8-methyl ether.

Free cortisone inhibited callus formation in a manner similar to that resulting from implanting antiauxin. Cortisone has a keto-alcohol structure. Antiauxin is also a keto-alcohol as indicated by chemical (*6*) and infrared (*7*) analyses.

A peculiar side effect was obtained with cortisone. Areas in the stem above the point of its application showed hypertrophy and accompanying necrosis of the cells. This condition was also induced by the implanting of testosterone, which is in effect the cortisone molecule minus the keto-alcohol structure.

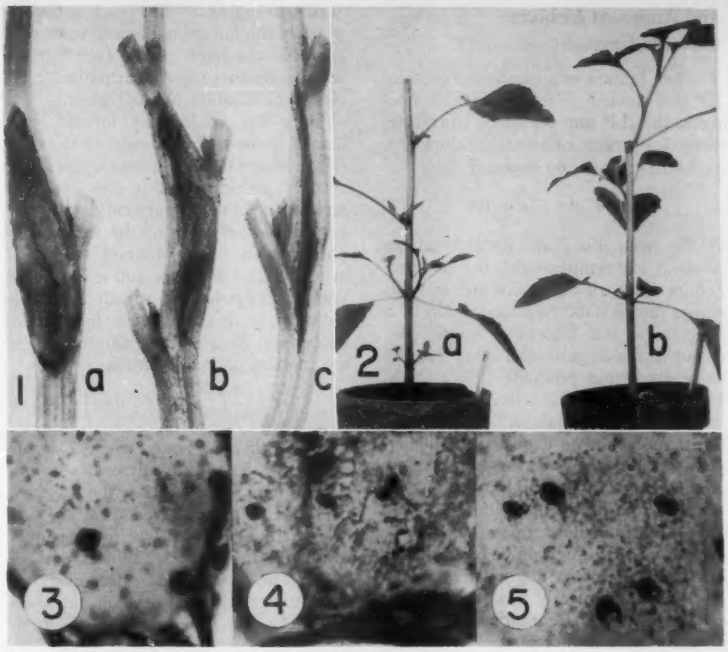

Fig. 1. Typical "callus" formation in slit stems of *Xanthium*; (*a*) large tumor 5 days after implantation of magnesium acetate; (*b*) small tumor growth in untreated slit; (*c*) no tumor was formed when antiauxin was applied. Fig. 2. Decapitated *Xanthium* plants; (*a*) inhibition of upper shoots by maleic hydrazide, 50 ppm; (*b*) same as *a* but also treated with antiauxin to neutralize maleic hydrazide effect, giving normal apical dominance. Figs. 3–5. Mitochondria in pith cells of stems of cocklebur. Fig. 3. Spherical or globular mitochondria in untreated plant. Fig. 4. Rod-shaped or filamentous forms of mitochondria in tissue treated with tumor-inducing substance. Fig. 5. Normal appearance of mitochondria when antiauxin was applied together with the stimulating agent.

The chemicals which stimulated tumor tissue development beyond that present in untreated plants are predominately fat soluble. Antiauxin, which inhibits proliferation, is also fat soluble. This suggests that callus or tumor growth is associated with a disturbed lipoidal metabolism. The mechanism involved would logically be, at least in part, cell or membrane permeability. Several chemicals, such as choline, caused bleeding from the implanted slits. This bleeding did not occur if antiauxin was also added.

The mitochondria in the pith cells had a different appearance in plants which had been chemically treated to produce cell proliferation. On the other hand, they appeared normal in plants that were kept from proliferating by the use of the antiauxin hormone, applied with the chemical (*4*, *8*) (Figs. 3–5).

The fact that the tissue is predominantly normal suggests the presence of a physiological mechanism having this function. It may be that antiauxin belongs to such a system. At least, it appears to be an aid to any natural host defense mechanism since it inhibits several types of chemically induced cell abnormality and the accompanying abnormal morphology. In addition, it has a role in producing maturation of erratically dividing plant tissue (*1*).

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Square Bubbles in Irradiated and Annealed Lithium Fluoride Crystals

When lithium or a compound containing this element is irradiated with neutrons, the $_3Li^6$ isotope, which constitutes about 7.5 percent of natural lithium (*1*), undergoes the (n, α) reaction (*2*)

$$_3Li^6 + {}_0n^1 = {}_2He^4 + {}_1H^3$$

If the irradiations are carried out on solids at low temperatures, the resulting helium and tritium gases are trapped within the crystals. As an extension of a program at our laboratory on the behavior of fission gases and other gaseous nuclear reaction products (*3*), a study has been made of the behavior of irradiated LiF single crystals on thermal treatment. As would be expected, at higher temperatures, the gases agglomerate to produce voids in the solid.

The shape of these cavities is, however, quite anomalous. Instead of spherical holes, which might have been anticipated, under certain thermal treatments the cavities are nearly *square,* approximately 0.01 to 0.02 millimeters on a side, and quite thin compared with their plane dimensions. When these cavities first appear, they are characterized by brilliant interference colors, indicating that their thickness is of the order of a few wavelengths of visible light, probably no more than 0.002 mm at most. No voids, spherical or plane, were observed in unirradiated LiF even when it was annealed for as long as 72 hours at 700°C or at temperatures near the melting point of the salt, 842°C (*4*).

To observe the square holes, LiF crystals obtained from the Harshaw Chemical Co. were irradiated in the reactor at Brookhaven National Laboratory at 30°C for integrated thermal neutron exposures of 1×10^{17} and 3×10^{18} neutrons/cm². The crystals were then heated in air. There was no difference between the two samples, except for the presence of more gas and more cavities in the specimens with the longer irradiation, as might be expected (*5*).

At 500°C, no agglomeration of gas or appearance of voids could be detected even after 72 hours of treatment and with magnifications of as high as 1000; at 660°C, in 15 hours, voids were readily observable at magnification of 150; and at 726°C, 3 hours was sufficient to produce voids that were easily visible under the same magnification (*6*). Figure 1 is a photomicrograph (*7*) of a crystal subjected to this treatment, showing the square bubbles. The white areas are faces of the cavities inside the transparent crystal; cavities at the surface appear dark. The edges of these squares tend to be parallel to the (100) planes of the crystal and appear predominantly at subboundaries rather than in sound portions of the subgrains or in regions adjacent to cracks. (Note crack in Fig. 1; possibly the failure to observe voids near cracks is the result of the fact that the latter constitute convenient paths for the escape of reaction product gases.)

Once the voids have formed, prolonged isothermal treatment of the crystals produces no significant change in the relative positions, but it does result in an increase in the population density and growth of the edges of the voids. This phenomenon was examined at 726°C after 3, 9, and 24 hours, and it was found that the edge-length growth is apparently linear in time and is in fact described by the equation, determined by the method of least squares,

$$L = (2.64 \pm 0.11) + 0.141t \qquad (1)$$

for t less than 25 hours, where L is the void edge length in microns, t is the time in hours, and ± 0.11 is the standard deviation of the observed from the calculated results. (This was for a sample irradiated to 3×10^{18} neutrons/cm² at 30°C. The interference colors observed when the cavities first develop disappear as this growth process progresses, indicating that the holes are increasing in thickness simultaneously with the increase in plane area.

With a constant annealing time, at increasing temperatures, precisely the same kind of growth is observed—that is, increase in the length of void edges and thickness, and no change in the relative positions of the square holes. This behavior was examined at four temperatures in the range 700° to 820°C, and the data, for the same irradiation time and temperature as in Eq. 1, and for a uniform annealing time of 15 hours, are described by the least squares equation

$$L = (-34.00 \pm 0.51) + 0.0582T \qquad (2)$$

for $700° < T < 825°C$. In this relation, T is the annealing temperature in degrees Centigrade, L is the edge length in microns, and ± 0.51 is the standard deviation. From Eq. 2, L is 0 at $T = 584° \pm 88°C$—that is, this is the minimum temperature at which bubbles would become visible after 15 hours of annealing. At higher temperatures, the cavities lose their square shape. Thus, after 15 hours, at 820°C the holes were observed to have rounded corners; and annealing for this time just below the melting point (842°C) resulted in the more intelligible formation of cavities with circular cross sections, presumably spheres. At 726°C, rounding of the corners of the squares was also observed, after 82 hours of treatment.

The mechanism by which these thin square cavities form and the reason for their observed alignment with the (100) crystallographic planes are not understood. This phenomenon has been observed to date only with irradiated LiF, and it is not known whether any other crystals exhibit this rather surprising behavior (*8*).

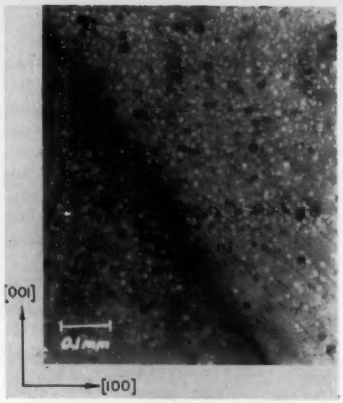

Fig. 1. Square bubbles in lithium fluoride.

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5. Crystals exposed to approximately 2×10^{19} neutrons/cm² become extremely turbid on thermal treatment (presumably because the density of the gas aggregates) and cannot readily be examined internally by microscopic techniques.
6. Samples annealed in a vacuum at about 5×10^{-6} mm-Hg showed no significant difference in the population and size of voids from those treated in air.
7. Examination of the crystals was made with a Bausch and Lomb metallograph, and photomicrographs were taken at magnifications of 150 and 250, employing standard photographic attachments.
8. The assistance of C. W. Tucker, Jr., and Leo F. Epstein is gratefully acknowledged.
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Experimental Infection of Rats with Streptobacillus moniliformis

Although *Streptobacillus moniliformis* has been isolated frequently from wild and laboratory rats, particularly from the lung, middle ear, and nasopharynx, it has been considered a commensal microorganism of low virulence for this host (*1, 2*). The microorganism has displayed virulence for human beings, most commonly following the bite of a rat, but

also after ingestion, and the infection has been characterized by fever, rash, and arthritis (*3–5*). High pathogenicity for mice has been demonstrated, and one means of identification of *Streptobacillus* is by the infection produced in mice, with resultant septicemia and joint involvement (*2, 4, 6*). The joint infection in mice is essentially an osteoarthritis and osteomyelitis, usually secondary to, or accompanying, a severe generalized systemic infection. Joint involvement accompanying systemic infections of man and animals by other microorganisms is also seen, although joint involvement alone may occur. An affinity of *S. moniliformis* for joint tissues of the developing chick embryo has been described (*7*). Attempts to infect rats with *S. moniliformis* via several routes have been unsuccessful, except for the occasional production of a localized lesion at the injection site (*2, 6, 8*).

During immunological studies with *Streptobacillus moniliformis*, a number of strains were isolated from naturally occurring lung and middle-ear infections in older laboratory rats. One recently isolated strain from a middle-ear infection (strain "C") has proved to be virulent for the laboratory rat and appears to have a specific predilection for joints, bone, and periarticular tissues. Upon intravenous injection with this strain, young rats developed a polyarthritis within 5 to 7 days, which subsided 10 to 30 days after the acute phase in most animals. The disease was produced consistently, in several experiments, in a high percentage of animals injected intravenously, but it was not produced by subcutaneous injection with the same strain.

Young Holtzmann-Fisher cross or Sprague-Dawley rats, 2½ to 3½ months old, were used. The Holtzmann-Fisher animals were offspring of rats which had been maintained on prophylactic doses of aureomycin for months, and neither parents nor offspring showed cultural or immunological evidence of natural infection with *Streptobacillus*. Cultures of *S. moniliformis* were carried routinely on rabbit blood agar, and in beef infusion broth adjusted to *p*H 7.6 to 7.8 and enriched with 20 to 30 percent sterile human ascitic fluid. These media were selected for producing the most consistent and abundant growth of the strains under investigation, after several other culture media and enrichment materials had been screened. Injections were made into the tail vein with 2.0 ml of an 18- to 20-hour beef infusion-ascitic fluid broth culture which had been inoculated from a 24-hour broth or blood agar stock culture.

Within 5 to 7 days after injection, rats developed redness, swelling, and tenderness of the affected joints. The degree varied from moderate to severe, and one to several joints showed involvement. Radio-carpal regions (wrists), tibio-tarsal regions (ankles), digits, and occasionally hips were affected, and some animals showed involvement of all four extremities at one time. Occasionally, the arthritis was migratory, disappearing from one joint only to appear in another. The incidence of clinically observed lesions in rats in five separate experiments is shown in Table 1. A total of 40 animals were injected intravenously, of which 37 animals developed gross joint changes. The clinically obvious joint involvement subsided within 10 to 30 days after the acute phase in most animals, although pathologic studies indicated that microscopic evidence of bone and joint involvement could persist long after grossly visible swelling and redness had disappeared. Microscopic study also revealed evidence of infection in and around joints which had never shown gross changes. Although the disease was reproduced consistently in a high proportion of animals injected intravenously, subcutaneous injection of the same doses produced no observable lesions.

Table 1. Joint lesions and cultures in rats infected with *Streptobacillus moniliformis*.

Experiment No.	No. arthritic/ No. injected	Percentage infection	No. positive/ No. cultured	Percentage recovery
28	5/5	100		
29A	5/5	100	3/3	100
29B	13/16	81.3	6/6	100
30	6/6	100	1/2	50
31	8/8	100	2/2	100
Total	37/40	92.5	12/13	92.3

Histologic study of a small number of infected animals showed an osteoarthritis, characterized by an acute inflammatory reaction at the sixth day, subacute to chronic at the 17th day, and chronic fibrotic and proliferative at the 33rd day. The component processes were an osteomyelitis, in most instances accompanied by periostitis, arthritis, and periarthritis. No lesions elsewhere than those described were found, either clinically or after detailed examination at autopsy.

Affected joints were ground and cultured at autopsy, and the infecting microorganism was recovered from the lesions in 12 of 13 animals cultured during the acute phase (5 to 11 days), and in one of two joints cultured after the acute phase had subsided (17 days). Of 16 heart blood cultures done at time of sacrifice, only one was positive. A degree of immunological response to the *Streptobacillus*, as evidenced by elevated plasma opsonin levels, has been demonstrated in infected animals.

This reproducible, high-incidence, infectious osteoarthritis of rats apparently specifically affects bones, joints, and periarticular tissues to the exclusion of all other tissues and organs, unlike the joint lesions found concomitantly with the generalized lesions of many systemic bacterial infections of man and animals. However, specific joint involvement has been shown with some other microorganisms. The production of an infectious osteoarthritis represents successful infection of the rat with *Streptobacillus moniliformis* at a site distant from injection. The natural occurrence of this microorganism in rats without evidence of systemic infection or joint involvement, and the characteristic joint involvement in human rat-bite fever caused by *S. moniliformis*, provoke interesting speculations about the role of infection in other arthritic conditions. The role of the filtrable "L" forms of this microorganism is at present under investigation.

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21 March 1957

Atmospheric Oxidation of Homogentisic Acid: Spectrophotometric Studies

Since Boedeker (*1*) first fully described and named the metabolic disorder alcaptonuria, it has been recognized that the urine of patients with this disorder contains homogentisic acid (2,5-dihydroxyphenylacetic acid) and tends to darken on exposure to air or upon addition of alkali. It is also well known that affected individuals virtually always

develop clinical evidence of ochronosis, a condition characterized by a striking dark brown-black pigmentation of the cartilages, tendons, and sclerae (*2*).

The pigment(s) thus formed have been broadly termed "melanins" (*3*), although no recorded attention appears to have been directed specifically to their nature or properties. However, unpublished observations (*4*) on the solubility characteristics of pigmentary material isolated by differential ethanol centrifugation from the urines of a family segregating for alcaptonuria (*5*) tend to suggest that alcaptonuric-ochronotic pigmentation may result from the selective deposition of one or more compounds having properties somewhat different from those usually attributed to the melanins resulting from the enzymic oxidation of, for example, *o*-diphenol derivatives (*6*). The present study was undertaken, accordingly, as a first approach to the chemical nature of the pigment(s) formed in alcaptanuric ochronosis.

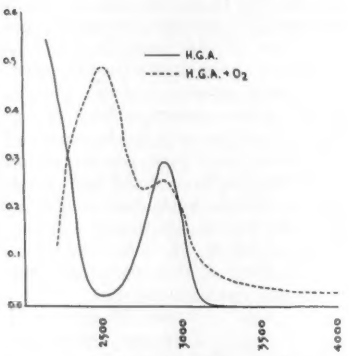

Fig. 1. Ultraviolet absorption spectra of pure homogentisic acid after partial interaction with molecular oxygen. The ordinate is optical density, and the abscissa is wavelength in angstrom units.

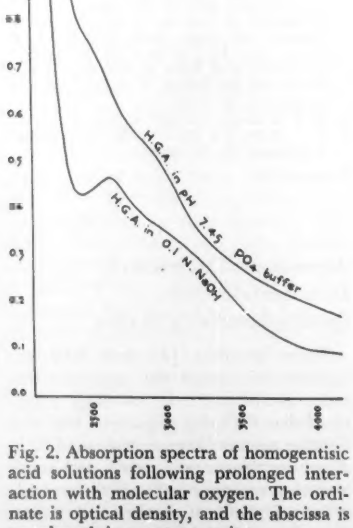

Fig. 2. Absorption spectra of homogentisic acid solutions following prolonged interaction with molecular oxygen. The ordinate is optical density, and the abscissa is wavelength in angstrom units.

Solutions of synthetic homogentisic acid [mp, 146° to 148°C; $\lambda_{max.}$, 2900 A (log ε, 3.58)] (*7*) were prepared in water (*p*H 4.8), phosphate buffers (*p*H 7.4 and 8.0), and 0.1*N* NaOH. Ultraviolet and visible absorption spectra were obtained at room temperature (25°C) with a model 14PM Cary recording spectrophotometer (*8*). Spectra were determined of freshly prepared solutions, of those which had been permitted to stand in air, and of solutions through which both oxygen and air had been passed for prolonged periods of time.

Homogentisic acid showed no absorption in the visible range in water or phosphate buffers, but it showed characteristic absorption at 2900 A, as has been previously reported (*9*). Freshly prepared solutions, however, failed to show absorption peaks other than at 2900 A. Following interaction with molecular oxygen, a second peak gradually developed at 2500 A which coincided with that reported for 1,4-benzoquinone-2-acetic acid, prepared by chromic acid oxidation of homogentisic acid (Fig. 1). The absorption curve obtained by subtracting the spectrum of pure homogentisic acid from the spectrum observed shortly after interaction of homogentisic acid with oxygen, moreover, was found to be identical with that of benzoquinoneacetic acid, thus indicating the presence of an intermediate mixture of both the hydroquinone and quinone derivatives in homogentisic acid oxidation.

Continued atmospheric oxidation resulted in the complete disappearance of the 2900-A peak, concomitant with progressive increase in the intensity of the 2500-A maximum. Additional exposure to molecular oxygen led to the appearance of an entirely altered absorption spectrum, quite unlike that of homogentisic acid in NaOH, that of benzoquinone-acetic acid in water or phosphate buffers, and those reported for ox-chorioid melanin, pigments isolated from black and red human hair, and for synthetic melanins prepared from tyrosine by the action of potato tyrosinase (*10*) (Fig. 2).

The present data would suggest, therefore, that homogentisic (hydroquinoneacetic) acid can be converted, in the presence of molecular oxygen and at physiological *p*H's, to the corresponding colored quinone, 1,4-benzoquinone-2-acetic acid. This appears, in turn, to be further oxidized to a more complex structure(s) having an absorption spectrum unlike those ascribed to certain of the naturally occurring melanins and to pigmentary material obtained by addition of alkali to homogentisic acid solutions.

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1 May 1957

Phototropic Auxin Redistribution in Corn Coleoptiles

Went and Thimann (*1*) have suggested several possibilities to account for the unequal lateral distribution of auxin found in plant parts which have been exposed to unilateral light. Among these are (i) light-induced auxin inactivation, resulting in a lowering of the auxin concentration on the lighted side; (ii) light-induced inhibition of auxin synthesis, having the same effect; and (iii) light-induced lateral transport of auxin from the light to the dark side. Early workers (*2*, *3*) felt that lateral transport of auxin played a major role in phototropic curvature. More recently, their conclusions have been reëxamined, and it has been suggested (*4*) that although the results cited provide support for the concept of lateral transport, it has not been unequivocally demonstrated. Studies by Galston and his associates (*5*, *6*) on light-induced inactivation of indole-3-acetic acid (IAA) have provided considerable evidence that photoinactivation of auxin may play a major role in phototropism.

In the present experiments (*7*), the auxin distribution in coleoptiles of corn (*Zea mays*, var. Burpee Snowcross) was studied in the dark and in unilateral light to determine the relative roles of the three afore-mentioned possibilities in effecting an auxin differential.

Corn seeds were surface-sterilized for 3 minutes in 3 percent Purex, rinsed in deionized tap water, and soaked for 4

hours. They were then germinated on moist filter paper under conditions of constant temperature (25° ± 0.5°C) and humidity (85 ± 1 percent). Only dim red light was used. When the primary roots were of sufficient length, the seeds were set in plastic trays, with the roots extending through holes into deionized tap water.

Preliminary experiments indicated that the coleoptiles showed a maximum growth rate when they were 90 hours old. Further experiments, using standard auxin diffusion techniques (*1*) with 4-mm coleoptile tips and standard agar blocks (8 by 11 by 1 mm), indicated that auxin production was also roughly maximum at 90 hours. Therefore, plants of this age, selected for coleoptiles approximately 16 mm long, were used in all subsequent experiments.

The phototropic sensitivity of coleoptiles of plants of this age was then determined. In three separate experiments, intact plants were placed in unilateral light. The measured light intensity at the coleoptiles was 21.5 meter-candles. Out of a total of 20 plants, all but six showed perceptible positive curvature at the end of 1¼ hours of light, and all showed curvature after 1½ hours. By the end of 3 hours, curvatures varied between 29° and 84°.

Further auxin diffusion experiments were done using 4-mm excised tips to determine the effect of unilateral light on the amount of auxin recoverable. The amount of auxin obtained from tips kept in the dark was compared with the amounts obtained from tips kept in the light for 1 to 3½ hours. Bioassay of the agar blocks from these diffusions, by the standard *Avena* test (*1*) showed no significant difference in the amount of diffusible auxin obtained from the illuminated tips, as compared with the dark controls (see Figs. 1*a* and 1*c*). Thus, if light-induced auxin destruction or inhibition of synthesis were reducing the amount of auxin diffusing from the light side of the coleoptiles, auxin production must be simultaneously increasing on the dark side to account for these results.

In order to determine the importance of light-induced lateral transport in determining the auxin differential associated with phototropic curvature, the technique of Went (*3*), and a modification, were applied to the corn coleoptile tips. The various diffusion experiments done are illustrated in Fig. 1. First, auxin was allowed to diffuse from sets of three intact tips into standard agar blocks for 3 hours. One such set was kept in the dark (Fig. 1*a*), and a second was kept in unilateral light, as described (Fig. 1*c*). Second, auxin was allowed to diffuse from sets of three tips which had been bisected longitudinally, under similar conditions (Figs. 1*b* and 1*d*). Third, six

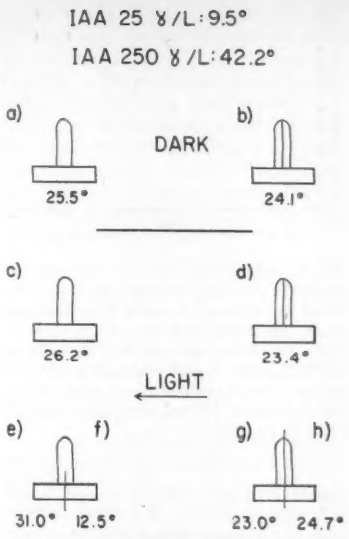

Fig. 1. Auxin diffusion experiments done with corn coleoptile tips. All diffusion times were 3 hours. (*a*) Three intact tips, dark; (*b*) three totally split tips, dark; (*c*) three intact tips, light; (*d*) three totally split tips, light; (*e*) six partially split tips, dark side; (*f*) six partially split tips, light side; (*g*) six totally split tips, dark side; (*h*) six totally split tips, light side. The numbers indicate amount of auxin obtained by diffusion into agar blocks, expressed as degrees of *Avena* curvature.

tips were partially split from the base to a depth of 1 mm. The bases were then separated by a No. 0 cover slip supported vertically between two microscope slides, in such a way that each half of each tip was in contact with a single standard agar block (Figs. 1*e* and 1*f*). Thus, each agar block was in contact with the bases of six half tips, the equivalent of the three tips in the previously mentioned diffusions. Finally, six tips were totally bisected, and the halves were placed on either side of a No. 0 cover slip, so that one-half of any given tip would be directly in the shadow of the other half when the experiment was placed in unilateral light. These sets of half tips were likewise allowed to diffuse on standard agar blocks, one on each side of the cover slip (Figs. 1*g*, 1*h*). The rows of partially split and totally split tips were then placed at right angles to the light source, so that the agar block on one side would collect the auxin diffusing from the dark halves of the coleoptiles, and the block on the other side, the auxin from the light halves. After the 3 hour diffusion period (a total light dosage of 125,000 meter-candle-seconds), all tips were removed, and the blocks were assayed by the *Avena* curvature test.

The results of such an experiment, in which the diffusions were done simultaneously, and the agar blocks then assayed simultaneously, are shown in Fig. 1. They are expressed as degrees of *Avena* curvature. The amounts of curvature obtained from standard blocks containing 25 and 250 μg of indole-3-acetic acid per liter are also shown. The standard error for all values shown was ± 1.92° or less.

There are several conclusions to be derived from these results. A comparison of the amounts of auxin obtained from diffusions 1*a*, 1*b*, 1*c* and 1*d* shows first that total splitting of the coleoptiles causes only a slight and insignificant decrease in auxin production; and second, that the amount of auxin produced was approximately the same, whether the tips were in light or dark for the diffusion time. Next, diffusions 1*e* and 1*f*, from partially split tips, show that light caused a strong difference in the amounts of auxin obtained from the light and dark sides, respectively, less auxin coming from the light side. However, auxin production per tip from diffusions 1*e* and 1*f* is only slightly less than the auxin production per tip from any of the controls (1*a*, 1*b*, 1*c*, and 1*d*). (On three other occasions, production per tip was the same as that of the controls.) These results concur with the observations of Went (*3*) for *Avena* coleoptiles. Perhaps most striking are the results obtained from diffusions 1*g* and 1*h*. When a total barrier is placed between the light and dark halves of the tips, there is no longer any difference in auxin yield between the two halves. As with the partially split tips, the total amount of auxin per tip did not deviate significantly from that of any of the controls.

Although it is possible to show only the results of a single experiment in this figure, the experiment has been repeated on four occasions, with comparable results.

It is felt that these results strongly suggest the following: under the conditions of light intensity, temperature, and humidity used, and with the variety of corn used, the lateral differential of auxin found in coleoptile tips exposed to unilateral light could be brought about only by light-induced lateral transport of auxin from the light to the dark side.

Three lines of evidence support this contention: first, 3 hours of light failed to reduce the amount of auxin produced by intact or totally split tips. Second, when the tips were partially split, a significant difference is noted between the amount of auxin diffusing from the light and dark sides, but the total amount of auxin produced per tip is either the same or only slightly lower than the amount per tip produced by intact controls. In view of the large amount of auxin obtained from the dark sides of the tips, and the almost total recovery of auxin

shown, it seems unlikely that either auxin destruction or inhibition of synthesis could be responsible for the observed differential. Third, when the tips were totally split, and an impermeable barrier was placed between the halves, unilateral light failed to produce any differential at all. Again, if either auxin destruction or inhibition of synthesis were responsible for the observed differential in the partially split tips, one would not expect a total barrier to make any difference in the amounts of auxin obtained. Thus, diffusions 1*g* and 1*h* should be comparable to 1*e* and 1*f*. The most reasonable explanation for these results is that unilateral light actually induces a lateral movement of auxin from the light to the dark side of the coleoptile, and in this way effects the observed auxin differential.

Further experiments are in progress to determine the effect of a range of light dosages on lateral auxin movement, and to attempt to determine in what part of the tip the lateral transport is occurring.

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7. This work was supported in part by a grant to one of us (W.R.B.) from the National Science Foundation.

24 May 1957

Method of Anesthetizing Large Sharks and Rays Safely and Rapidly

In the course of an experimental study dealing with the influence of the anterior pituitary on mating behavior and reproduction in elasmobranchs, it recently became necessary to handle sharks and rays of considerable size. Of the many tranquilizers and anesthetics that were tried, the narcotic known commercially as M.S. 222, a meta-amino-benzoic acid-ethylester in the form of a methan-sulfonate, proved to be the most useful (*1*).

For a quarter of a century, M.S. 222 has been used by the experimental embryologist as an anesthetic for amphibian embryos and small teleosts. Rothlin (*2*) notes that it is isomeric with anesthesin, 3 times less toxic than Novocain, 10 times less toxic than cocaine, and highly

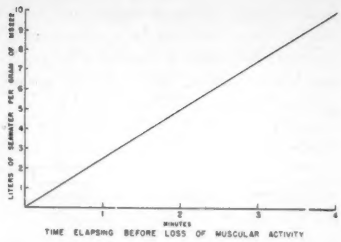

Fig. 1. Relationship between the concentration of M.S. 222 utilized and the rapidity of its action on a young female lemon shark. An initial dose of 100 ml of M.S. 222 solution was sprayed over the gills at the beginning of each experiment. When weaker concentrations were used, additional doses of 100 ml were administered every 60 seconds.

soluble in water. McGovern and Rugh (*3*), using a dilution of 1/3000 on frog eggs and sperms, found that M.S. 222 does not affect sperm motility and fertilizing power, nor does it have any effect on ciliary action; however, it does act quickly on skeletal muscle and effectively immobilizes frog embryos immersed in the solution in 30 to 80 seconds. Schotté and Butler (*4*) point out that M.S. 222 is of great value as an anesthetic in experiments with urodele larvae, since a stock solution of 1/1000 may be sterilized in the autoclave without loss of its narcotic properties and with no increase in toxicity. These investigators have "often kept animals for two consecutive days, and longer, in a 1/10,000 solution without ill effects. Moreover, no cumulative effects have been observed, inasmuch as the same larvae have frequently been submitted to a total duration of 10 days of narcosis within a single month." Many others, including Christensen (*5*), Copenhaver (*6*), Glucksohn (*7*), Rotmann (*8*), Sato (*9*), and Witschi (*10*), have successfully employed M.S. 222 as an anesthetic by simply immersing amphibian embryos or small teleosts in a solution of 1 g of M.S. 222 dissolved in 3000 ml of spring water.

Because of the large size of the elasmobranchs that were investigated, complete immersion in a solution of M.S. 222 was out of the question. An alternative method of utilizing this narcotic was therefore developed, and because of the ease with which it is applied while the fish is still vigorously straining at the hook or harpoon in the water alongside the boat, because its action is dramatically prompt, and because recovery after narcotization is invariably complete, we believe our method may be of some interest and value to others (*11*).

For the most rapid results, a concentration of 1/1000 (1 g of M.S. 222 in 1 lit of sea water) is utilized. On smaller species, 100 ml, and on larger fish, up to 1 lit, of this solution is introduced into the mouth of a shark or the spiracles of a ray and sprayed over the gill exits of the pharynx by means of a water pistol, rubber-bulb syringe, or small, pump-type hand sprayer. During the period of application, the head of a large fish should be held above the level of the water by means of a gaff or the leader that is attached to the hook or harpoon point; smaller fish may be temporarily removed from the water. The drug is quickly absorbed by the gills, and its action is rapid. Within 15 seconds the M.S. 222 solution begins to take effect and, as a rule, even a 400-pound shark is anesthetized in 1 minute or less. The shark or ray may then be readily handled, either out of or in the water, until the first stage of recovery takes place, within 5 to 30 minutes after the animal is returned to the water; this varies with the size of the elasmobranch and the dosage. Recovery may be delayed with an additional application of M.S. 222 solution at this time or may be hastened by washing the gills with fresh sea water (either by "walking" a large shark, with its mouth kept open, around the pool or by directing a stream of fresh sea water into its mouth).

Figure 1 is based on a series of tests in which concentrations ranging from 1/1000 to 1/10,000 were used on a lemon shark (*Negaprion brevirostris*) that weighed 9½ pounds. A 1/1000 concentration of M.S. 222 solution acted in approximately 20 seconds, while weaker concentrations of M.S. 222 solution acted much less rapidly. When the recommended 1/1000 concentration of M.S. 222 solution is utilized, the size of the dose needed to anesthetize a shark or ray within 1 minute is suggested in Fig. 2.

M.S. 222 has been employed effectively on four genera of sharks and two genera of rays, and, in every case, recovery has been complete and the fish appears to have been quite unharmed by

Fig. 2. Size of dose of M.S. 222 solution (1/1000 concentration) recommended to anesthetize a shark or ray in 60 seconds or less. The solution should be sprayed over the gill exits of the pharynx while the head of the elasmobranch is held above the level of the water. If the head remains under water, proportionally stronger concentrations must be utilized.

the treatment. Sharks have been kept alive for as much as 1 month after treatment and have shown no ill effects.

The advantages of this simple method for anesthetizing elasmobranchs are obvious. M.S. 222 is easily applied to the gills by way of the mouth or spiracles and acts rapidly on large or small fish (*12*), and recovery is gradual and invariably complete. It would appear that this drug, and the method of application we have outlined here, might be useful not only to the experimental zoologist but to those concerned with capturing large fish, either for exhibition purposes or for food (*13*).

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References and Notes

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11. This study was initiated by both authors at the Marineland Research Laboratory and was subsequently carried on by the senior author at the Lerner Marine Laboratory, Bimini, Bahamas. It was supported, in part, by a grant from the National Science Foundation.
12. M.S. 222, applied in this manner, also works effectively on teleosts of various sizes.
13. M.S. 222 does not make the flesh unpalatable, and fish that have been anesthetized with M.S. 222 have been consumed with no deleterious effects.

* Guggenheim fellow, 1957.

6 June 1957

Fundamental Limit to Certainty in Scientific Generalizations

It is of theoretical interest, at least, to consider the degree of certainty that can be attained for a scientific generalization. In this report, the derivation of a maximum confidence limit for a generalization is described (*1*).

Let U and X designate two combinations of one or more variables each, which may be divided into d and e mutually exclusive, observed classes, respectively. Class widths need not be equal. Values d and e may be as large as desired, subject to limits of observation, but let $d \geqq e$. Now, an apparently perfect relationship between U and X would be indicated if it were observed that for each of n_i occurrences of U which fall into a given class U_i, the concurrent (or subsequent) occurrence of X falls into just one class X_j, and this were true of every U_i and X_j. Here, U_i can be regarded as a hypothetical infinite population from which a random sample n_i has been obtained. According to the statistical method of confidence limits (*2*), then, a lower confidence limit P_i to the "true" (population) probability for X_j to be observed when (or after) U_i is observed, is given by

$$P_i = \left[\frac{1-S}{2}\right]^{\frac{1}{n_i}} \qquad (1)$$

where S is defined as the confidence level. Limits for P_i and S are 0 and 1. A value of S is chosen subjectively; 0.95 and 0.99 are frequently used.

A lower confidence limit $\overline{P}_i$ for the apparently perfect relationship between U and X can be defined as the arithmetic average of all d of the P_i's. By means of first and second derivatives of $\overline{P}_i$ with respect to n_i (*3*), with S, d, and N (the total number of observations) held constant, it is found that $\overline{P}_i$ is a maximum when all n_i's are equal to each other (*4*). It follows that

$$P = \left[\frac{1-S}{2}\right]^{\frac{d}{N}} \qquad (2)$$

where P is the maximum value of $\overline{P}_i$. P increases as N increases or as d decreases. (In general, now, d may be regarded as the maximum number of observed classes of any factor or combination of factors in the relationship.)

A simple example will illustrate the use of the last equation. Consider an idealized situation in which it is observed that barometric pressure gives perfect predictions of weather at a given location. Let the weather (X) there at noon be classified as *rain, changeable,* and *fair* ($e = 3$); and the pressure (U) there 24 hours earlier be classified as *low, intermediate,* and *high* ($d = 3$). A total of 750 independent forecasts (N) are available to show that low, intermediate, and high pressure invariably preceded rain, changeable, and fair weather, respectively. With just this information and a value of 0.95 for the confidence level S, Eq. 2 can be used to find a maximum confidence limit $P = 0.985$ for pressure as a predictor. In effect, this means the chances are 95 out of 100 that the seeming perfection of the observed relationship between noon pressure and subsequent weather at the given location is at least 98.5 percent certain, provided that the forecasts are distributed equally among the three pressure classes. No stronger statement of confidence can be made in this case; if the distribution is unequal, there is less certainty.

Note that when $d = e = 1$, P is the maximum confidence limit for an event observed to happen the same way each time, under the same circumstances.

As is indicated by Wilson (*5*), "All sciences start with a process of selection or classification. . . . Furthermore, all scientific laws are based on classifications." And Caldin (*6*) states that "The elementary generalisations on which science, considered as a system of beliefs about nature, is dependent, are derived from observations by generalisation . . . a process . . . treating observations not as bare data but as signs of a regularity; leading not to certainty, but to likelihood. . . ." However closely a scientific generalization describes observed regularity, and however perfect the regularity appears to be, absolute certainty for the generalization cannot be claimed. At best, the degree of uncertainty is as small as the uncertainty in the regularity. The latter uncertainty is given by Eq. 2 in terms of a maximum confidence limit. This leads to the interesting conclusion that, in the final analysis, this expression furnishes a maximum confidence limit for the generalization—law, hypothesis, or theory.

It is apparent that such an analysis could be quite complicated, particularly in the more advanced sciences, chemistry and physics (*7*). But this complication does not invalidate the conclusion.

Finally, it can be noted that Eq. 2 is relevant too for a regularity wherein assumptions of random, independent samples (required by statistical theory) and objective, rather than subjective, classifications, are not fully satisfied. In that event, the computed value of P still is a maximum confidence limit not to be exceeded, for it is the closest possible approach to certainty when S, d, and N are specified.

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References and Notes

1. The work in this report was supported, in part, by the Geophysics Research Directorate of the Air Force Cambridge Research Center under contract No. AF19(604)-753. A more detailed derivation of Eq. 2 in this article has been given, with application to weather prediction [T. A. Gleeson, *J. Meteorol.* **14** (Aug. 1957)].
2. A. M. Mood, *Introduction to the Theory of Statistics* (McGraw-Hill, New York, 1950), p. 234.
3. It is assumed that the n_i scale is continuous rather than being composed of whole numbers. This assumption is deemed sufficient for the present purpose.
4. Furthermore, each $n_i > -\frac{1}{2}\log_e\left[\frac{1-S}{2}\right]$. This condition is easily satisfied in practice. For example, if each n_i were as small as 4, S could be chosen as high as 0.999.
5. E. B. Wilson, *An Introduction to Scientific Research* (McGraw-Hill, New York, 1952), p. 151.
6. E. F. Caldin, *The Power and Limits of Science* (Chapman and Hall, London, 1949), p. 69.
7. For discussions of the complexities involved here, see E. B. Wilson (*5*, section 7.5) and M. R. Cohen and E. Nagel, *An Introduction to Logic and Scientific Method* (Harcourt, Brace, New York, 1934), chap. 14.

3 May 1957

Book Reviews

The Climate near the Ground. Rudolf Geiger. Translated from the second German edition of *Das Klima der bodennahen Luftschicht,* with revisions and enlargements by the author, by Milroy N. Stewart *et al.* Harvard University Press, Cambridge, Mass., rev. ed. 2, 1957. xxi + 493 pp. Illus. $6.

It is just 30 years since the first German edition of *Das Klima der bodennahen Luftschicht* appeared—a rather slender volume of 245 pages. In the meantime microclimatology, which is the main theme of this book, has seen much growth. The interesting relationships between climate, on one side, and plant life and human activities on the other have stimulated a great deal of research. Rudolf Geiger, who now teaches at the University of Munich, and his pupils have made many fundamental contributions in this field, especially to those aspects that pertain to forestry.

It is no exaggeration to call this book a classic treatise. Among the important topics covered are the basic features of the radiation and energy balance of the layer of air near the ground. The characteristics of temperature, humidity, and wind, in and just above the boundary layer, are thoroughly reviewed. The influence of ground cover, water bodies, and topography on the microclimate are clearly elaborated. The interactions of natural plant cover, crop plants, and forests with the atmospheric environment are given a lucid appraisal. Less emphasis is placed on the microclimate of human habitations, although the most important fundamentals of this phase are mentioned. Correction of adverse microclimatic conditions through control measures is also touched on, with particular reference to the prevention of frost damage.

The book is written in simple style. It is almost entirely without the heavy mathematical fare that has become such a necessity in the sister science of micrometeorology. This makes it readily understandable to readers in the biological and ecological disciplines as well as to climatologists and meteorologists. This is accomplished without sacrifice of accuracy.

With its many illustrations, it makes an ideal introductory textbook. For this particular purpose, the fact that the second American printing of the translation of the 1940 German (second) edition is not entirely up to date is not too serious. The approximately 500 references (to 1956) which were added to the original 800 of the first printing make the bibliography a very valuable part of the book. However, literature citations alone do not compensate for text. Even in the third German edition (1950) there are important additions to be found, particularly in the section on interrelations between the animate world and the microclimate. These include data on animal flight, room climate, and windbreaks. These criticisms should probably be laid at the doorstep of the publishers rather than of the author. This also applies in the case of the translation, which could be improved on.

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Botany. An introduction to plant science. Wilfred W. Robbins, T. Eliot Weier, and C. Ralph Stocking. Wiley, New York; Chapman & Hall, London, rev. ed. 2, 1957. 578 pp. Illus. $6.95.

The second edition of Wilfred Robbins' and T. Elliot Weier's *Botany,* with C. Ralph Stocking as an additional author, is about 100 pages longer than the first. Seven years have elapsed since the first edition came out, and, considering the number of discoveries and clarifications of older ideas which have been made by botanists, biochemists, biophysicists, and microbiologists during this period, the small increase in the number of pages is a testament to the authors' rigorous selection of topics to be discussed. However, this book, like many others, is still an attempt to satisfy the expressed, or assumed, demands of teachers for a bit of everything. Despite the prefatory statement that it is intended to complement the instructor, not to provide a complete, although introductory, coverage of botany, I cannot help but feel that, in dipping into so many aspects of plant life and of the importance of plants to man, the authors have made it difficult for a teacher to plan lectures and laboratory work which will not be repetitious for the students who faithfully read the book.

There is one point of view expressed in the preface (page viii) and in Chapter 1 (page 3) with which I would like to take issue. It concerns the meanings of the word *botany* and of the words *plant science.* The authors do not consider them synonymous, as they are considered in dictionaries and in general usage. They make botany a restricted part of plant science by defining it as the part "which deals with the basic information concerning plants. [Botany] considers plants for their own sakes without an immediate consideration of their usefulness." They define "plant science" as the "collection of information concerning all phases of the growing and processing of plants." They further explain that plant science includes "the structure, reproduction, chemistry, breeding, disease, physiology, processing, and distribution of plants or plant parts."

The inclusion of processing of plants or plant parts in the definition of plant science seems to me to be presumptuous and unnecessary. I doubt that the chemical engineer who is concerned with processing starches, celluloses, resins, and so on, wants to be called a plant scientist. More disturbing, however, is the implication that a botanist is a "pure" scientist, aloof from, and uninterested in, the usefulness to man of information about plant structure and functioning. If there are such botanists today their viewpoint is tragically shortsighted, and they must be oblivious of the world in which they live, with its problems of food shortages and plant, animal, and human malnutrition and disease. A "botanist" and a "plant scientist" should be one and the same person. Let us make it clear to students and to the public that botanists are plant scientists and let us educate them, if they need such education, to know that botany is the science of plants, *all* of that science. The world needs broadly trained botanists, who will learn everything they can about growth, development, and reproduction of every kind of plant, in order that we may have a chance to have the information we need for whatever practical problem may arise.

The main body of this textbook is planned and written in the pattern now common for general botany textbooks. Whether or not this is the best pattern should probably not be discussed in a review of one particular book. Suffice it to say that this one is a good example of the type.

In the first chapter, it introduces the student to the field, justifies the study of plants by modern man, and delineates

the approach which the rest of the book is to follow. Chapters 2 and 3, on "The plant world" and "Classification and naming of plants," are good ones to have at the beginning, for they allow teachers who want to start the course with field work—to familiarize students with plants and to teach them to see the world of plants in which they have been blindly living—to do so, with reading of these chapters assigned to complement and extend the laboratory work.

The authors, wisely, I think, discuss flowering plants in the next 12 chapters, enabling the teacher who uses the book to capitalize on the common interest of students in the plants that are conspicuous in their lives and clearly valuable to man. The illustrations are good, well selected, and sufficiently numerous so that it is not necessary for a student to make many drawings for himself in order to have some means of recalling what it is hoped he has had time to see in the laboratory. It would be most unfortunate, however, if a well-illustrated textbook were substituted for observation of living plants and for study of prepared slides of parts of them.

As might be expected, the rest of the book is a survey of the plant kingdom (including the viruses) and ends with a chapter on evolution. This portion of the book, although it contains a good deal of detail, is made more interesting for the student (I would think) than are similar surveys in many books. The importance of unfamiliar plants to man's activities is stressed. A teacher might skim over a few of the life-histories, which are diagramed, and use them only to put across the definite point that there are similarities and differences in the ways in which different kinds of plants maintain themselves. The descriptions and illustrations of the more common families of flowering plants would fit in with field work, which might well come in the spring of a year's course in botany.

In this revised edition, many of the errors noted in the first edition have been removed. A few remain, over which one could quibble, and a few have been introduced in the rewriting of portions to add new material. Some sentences still remain which are correct if a reader knows how to interpret them but which might mislead a student who is unfamiliar with the subject.

A final word must be said about the glossary and the index. Both are very complete. Furthermore, in the glossary, the language from which we have derived each term is noted, and the meaning of the word in that language is given. Thus, an interested student can develop a feel for botanical terminology and a competence in its use.

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Physical Techniques in Biological Research. vol. II, *Physical Chemical Techniques.* Gerald Oster and Arthur W. Pollister, Eds. Academic Press, New York, 1956. 502 pp. Illus. $12.80.

Physical Chemical Techniques, the second volume in this series, deals with select physicochemical techniques which are employed in elucidating the nature of molecular structures that occur in biological systems. Like its predecessor volume, it is composed of a series of essays, written by individual contributors who have made contributions to, and extensive application of, the methods described.

The first two chapters are devoted to the use of stable and radioactive isotopes as tracers for following the distribution and uptake of labeled compounds. Both sections introduce the subject with extensive surveys of radioactive phenomena *per se,* which would appear to be unnecessary for the advanced worker to whom the text is addressed. One would like to see the space devoted to a more extensive discussion of the methodology to specific biological problems.

It would appear from the nature of the bibliographies and from antiquated statements in the text that many of the sections were prepared 3 or 4 years prior to the publication of the book. Thus, in describing the mechanism of beta-decay, the neutrino is described as a mathematical concept invoked to conserve momentum. No mention is made of the convincing experimental evidence for the existence of this fundamental particle that has been established during the past 2 years with the aid of the large atomic piles as sources for these elusive particles.

In a description of autoradiographic techniques, the growth of fog with the aging of the recording medium is attributed to the cosmic radiation. While this is a contributing factor, particularly in laboratories located at high elevations, the major part of the noise originates from chemical and mechanical effects, often unwittingly increased by storage of the film in proximity to x-ray machines and radioactive sources.

The greater part of this volume is devoted to concise, highly informative treatments of sedimentation, diffusion, and viscosity as means for securing information about the nature of complex solutes. Other techniques for the *in vitro* study of protein systems are presented; these include the preparation of surface films, adsorption phenomena and chromatography, electrophoresis, the measurement of electric potentials originating at membranes and phase boundaries, and the use of x-ray diffraction methods in the study of large biomolecules, such as cellulose and the nucleic acids.

A rather unexpected and welcome addition is a section on magnetic methods applicable to biological materials that possess appreciable paramagnetic properties. At one time, this experimental approach was limited to select problems in mineralogy and inorganic chemistry, such as the separation of certain mineral grains from gangue, or in the analysis of rare-earth elements that possess distinctive magnetic susceptibilities. With the current availability of more powerful magnetic fields and more sensitive methods of measurement, it is now possible to secure information on the magnetochemical behavior of nucleic acid constituents, and paramagnetic resonance methods can be applied fruitfully to the study of the structure of hemoglobin and related metalloporphyrins.

The basic value of this volume resides in the presentation of the scope of diversified techniques, which, in this age of specialization, may not always be within the ken of the individual investigator. Its study may reward the reader with some new experimental approach that will contribute to the solution of the difficult analytic problems that are associated with biochemical research.

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Technical Aspects of Sound. vol. II, *Ultrasonic Range, Underwater Acoustics.* E. G. Richardson. Elsevier, Amsterdam, 1957 (distributed in the United States by Van Nostrand, Princeton, N.J.). 412 pp. Illus. $11.75.

This is the second volume of a very comprehensive work on various aspects of sound technology. It continues, in the fields of ultrasonic applications, underwater acoustics, and aircraft noise, the "handbook" treatment that was given airborne and sonic range acoustics in the first volume.

The second volume starts with a chapter by E. G. Richardson, who contrasts the propagation of sound in the air and in sea water and points out some of the fundamental mechanisms that determine the transmission of sound in large bodies of water. In division I are two chapters, by B. E. Noltingk and N. B. Terry, who discuss methods for producing ultrasonic vibrations in liquids and solids, and a very complete account of the uses for such vibrations. These include flaw detection, gaging, elastic property measurement, machining, cleaning and dispersion, and chemical and biological effects.

In division II are described the techniques of measurement and absorption of

sound waves in water. E. Meyer contributes two chapters, one on instruments for measuring the transmission properties and the other on the effects of air bubbles on sound transmission in water. Bubbles can have a marked effect on sound transmission and, in the limit of high sound intensity, produce the phenomenon of cavitation. A chapter by K. Tamm discusses the various linings that have been used to absorb sound waves in tanks used for underwater sound measurements. The "Fafnir" construction used in German technology is emphasized. The section closes with an account by H. Oberst of the resonant sound absorbers that were used to reduce the reflections from German submarines during World War II.

A third division, by A. A. Regier, H. H. Hubbard, and L. W. Lassiter, covers the timely subject of aircraft noise. Noise from propellers, engines, jets, rocket motors, and sonic "booms" are discussed and compared. A final chapter, by Richardson, discusses the sound of propulsion in water.

It seems to me that the objective of producing a handbook to cover all the technical aspects of ultrasonics, underwater sound, and airplane noise is admirably achieved. The separate writers are all well-known experts in their fields and produce an authoritative account of their subjects. The book should be very useful and should have a wide sale among engineers and physicists working in these fields.

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Handbook of Snakes of the United States and Canada. vols. 1 and 2. Albert H. Wright and Anna A. Wright. Comstock; Cornell University Press, Ithaca, N.Y., 1957. 1105 pp. Illus. $14.75.

Virtually every naturalist dreams, at some time during his career, of writing a great compendium, a thorough, outstanding reference work on his chosen subject. Albert Hazen Wright had such a dream four decades ago. Unlike the vast majority of his colleagues, he had the persistence and knowledge for translating vision into reality. And in the process he became the inspiration for an entire series of volumes on herpetology —the Comstock handbooks, which are almost indispensable for anyone deeply interested in this field.

In coauthorship with his wife, he first produced the *Handbook of Frogs and Toads of the United States and Canada*, now in its third edition, and the same team has just given us the two-volume *Handbook of Snakes*. A third volume, containing a bibliography of North American ophiology, is soon to be published. (Other authors produced the handbooks of salamanders, turtles, and lizards, but they drew heavily on the Wrights' photographic library and on their advice and counsel.)

One must admire the Wrights' tenacity in seeing this work to its fruition despite innumerable difficulties, not the least of which has been a rapid acceleration of interest in North American herpetology and a resultant flood of papers on serpents. Another problem was that of obtaining living, healthy specimens of almost every species and subspecies of the area. Each of these is illustrated by generally excellent photographs that show, in most instances, the top, side, and under surface of the head, three similar views of the body, and a portrait of the serpent taken from directly above, plus, in a great many cases, a ventral view. These make the book unquestionably the most thoroughly illustrated in its field, and, since the publishers have provided a better grade of paper than in other books of the series, the reproduction is first-rate. There are also dozens of line drawings that illustrate details of serpentine anatomy, and there are maps that show the geographic distribution of the 305 different forms included in the book.

The text is based on wide experience in the field and laboratory, visits to the major museums of the United States, and several years of peregrinations through the herpetological literature. In fact, the book is so thoroughly documented that sometimes the reader must make his choice between conflicting statements of opposing authors. The original manuscript was so long that a considerable portion of it had to be excised in the interests of economy of space. What is left is meaty and well organized under such subheadings as range, size, distinctive characteristics, color, habitat, period of activity, breeding, food, and authorities. The recommendations of the Committee on Herpetological Common Names of the American Society of Ichthyologists and Herpetologists were published too late to be used; hence, the *Handbook of Snakes*, in spite of the important place it is bound to have in the history of herpetology, will not aid in achieving the standardization of common names that seems so highly desirable.

Despite the fact that much of the book was written years ago, the Wrights have made a notable effort to keep it up to date. In many instances, recent papers are mentioned, with appropriate comments, even though they were published after the manuscript for the *Handbook* had been completed. This results in some inconsistencies, for the distribution maps do not always reflect the latter-day statements in the text. There are a few minor errors, as is inevitable in a large book of this sort, but I believe that a reviewer should report such errors directly to an author rather than follow the common, but dubious, custom of enumerating them in print. Certain practitioners of polemics seem to delight in listing all manner of minutiae merely to impress their colleagues with their ability to find mistakes.

As a general reference work on North American serpents, as a valuable aid in identifying the different species and their races, and as an outstanding example of pertinacity despite many difficulties, the *Handbook of Snakes* will be indispensable for any naturalist or, for that matter, any natural history library. The third volume, when it is published, will be *the* key to the technical literature on the snakes of the United States and Canada.

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Handbuch der Physik. vol. XXX, *X-rays*. S. Flügge, Ed. Springer, Berlin, 1957. 384 pp. Illus. DM. 88.

This comparatively thin volume of the *Handbuch der Physik* is entitled simply *X-rays*. There are five sections, dealing with the various aspects of the subject; all of these are in English except for the first, which is in German and deals with the production of x-rays. The second section is entitled "Experimental methods of x-ray spectroscopy at ordinary wavelengths." The third section, "Experimental methods of soft x-ray spectroscopy and the valence band spectra of the light elements," is followed by a section on "X-ray microscopy." The last section is a discussion of "The continuous x-ray spectrum."

It would be both tedious and superfluous to comment in detail on the contents of this volume. Each section is complete and thorough. In discussing the production of x-rays, Schaaffs (76 pages), after a very brief historical introduction, discusses the properties of x-rays and the techniques which have been and are being used for their production. Of the five sections, this is the one which, for the most part, deals, of necessity, with older papers, since this is the area which has been longest under study.

In the second section, Sandström (163 pages) deals with experimental methods of x-ray spectroscopy at the more common wavelengths, leaving the very soft part of the spectrum to Tomboulian (59 pages), who follows him in this volume. Both of these subjects, while long established, are fields in which very active

work is being carried on today; both reviews are thoroughly up to date. These sections will be referred to constantly, particularly because of the extensive tables of wavelengths of emission lines (including satellites), wavelengths of absorption discontinuities, energy levels, and band widths which are included.

Kirkpatrick's fundamental work in x-ray microscopy is, of course, well known, and I was pleased to find in this all too brief section ("X-ray microscopy," 29 pages), for which Kirkpatrick and Pattee were responsible, a discussion of techniques which possibly may not be properly classified as x-ray microscopy. There is a discussion of microradiography, of x-ray projection microscopy, and of the focusing microscopes.

The concluding section, by Stephenson (52 pages), on "The continuous x-ray spectrum" is, for the most part, devoted to comparatively early work, although appropriate attention has been paid to more recent developments.

The final 14 pages consist of a dual index, in German and English, which will prove very useful to English-speaking readers whose knowledge of German may not be adequate.

On first reading the table of contents of this volume, I was frankly disappointed at some of the authors who had been chosen to write some sections; I would perhaps have chosen others. However, the wisdom of the choice is finally decided by the quality of the product. There is apparently something about the *Handbuch der Physik* which is very special: being asked to contribute to it apparently brings out the best in an author. All the papers are excellent and adequately detailed and, in spots, even make enjoyable reading. The choice of authors, therefore, was a happy one.

I. FANKUCHEN
Polytechnic Institute of Brooklyn

Books Reviewed in The Scientific Monthly, August

An Introduction to Cybernetics, W. R. Ashby (Wiley). Reviewed by J. Rothstein.

The Criminal, the Judge, and the Public, F. Alexander and H. Staub (Free Press). Reviewed by F. Wertham.

Through Soviet Windows, J. E. Evans (Dow Jones). Reviewed by W. S. Vucinich.

Logic without Metaphysics, E. Nagel (Free Press). Reviewed by J. Turner.

Eisame Inseln: Eine Forscherfahrt im Persian Gulf, H. Heberlein (Orill Fussli). Reviewed by W. R. Holleman.

Medical Research: a Midcentury Survey, vol. 1, *American Medical Research: in Principle and Practice*; vol. 2, *Unsolved Clinical Problems: in Biological Perspective,* E. E. Lape, Ed. (Little, Brown). Reviewed by B. Glass.

Common Frontiers of the Social Sciences, M. Komarovsky, Ed. (Free Press). Reviewed by B. H. Williams.

Machine Literature Searching, J. W. Perry, A. Kent, M. M. Berry (Western Reserve Univ. Press). Reviewed by K. F. Heumann.

The Land Called Me, E. J. Russell (Allen and Unwin). Reviewed by P. B. Sears.

Principles of Engineering Heat Transfer, W. H. Giedt (Van Nostrand). Reviewed by G. A. Hawkins.

Mission on the Nile, J. Dempsey (Philosophical Library). Reviewed by H. T. Straw.

Grasslands of the Great Plains, J. E. Weaver and F. W. Albertson (Johnson). Reviewed by H. G. Reynolds.

Weather, P. Lehr, R. W. Burnett, H. S. Zim (Simon and Schuster). Reviewed by S. S. Visher.

New Books

Radioastronomie. Raymond Coutrez. Edition du Patrimoine de l'Observatoire Royal de Belgique, Uccle, 1956. 391 pp. F. 250.

Lecture Notes on the Use of the Microscope. R. Barer. Thomas, Springfield, Ill., ed. 2, 1956. 76 pp. $1.50.

Organic Chemistry. Louise Kelley. McGraw-Hill, New York, ed. 2, 1957 (ed. 1 by G. Albert Hill and Louise Kelly). 765 pp. $7.50.

Comprehensive Inorganic Chemistry. vol. 6. *The Alkali Metals.* John F. Suttle. *Hydrogen and Its Isotopes.* Robert C. Brasted. Van Nostrand, Princeton, N.J., 1957. 242 pp. $6.

Cell Physiology. Arthur C. Giese. Saunders, Philadelphia, Pa., 1957. 552 pp. $10.

Mathematics for Everyman. From simple numbers to the calculus. Egmont Colerus. Translated by B. C. and H. F. Brookes. Emerson Books, New York, 1957. 266 pp. $3.95.

Educating Gifted Children. Robert F. DeHaan and Robert J. Havighurst. University of Chicago Press, Chicago, Ill., 1957. 285 pp. $5.

The Beginnings of Chinese Civilization. Three lectures illustrated with finds at Anyang. Li Chi. University of Washington Press, Seattle, 1957. 140 pp. $6.50.

The Astonished Muse. Reuel Denney. University of Chicago Press, Chicago, Ill., 1957. 271 pp. $4.50.

The Logical Problem of Induction. Georg Henrik von Wright. Macmillan, New York, ed. 2, 1957. 261 pp. $4.

The Science of Engineering Materials. J. E. Goldman. Wiley, New York; Chapman & Hall, London, 1957. 543 pp. $12.

The Modern Researcher. Jacques Barzun and Henry F. Graff. Harcourt, Brace, New York, 1957. 399 pp. $6.

General Chemistry. A. W. Laubengayer. Rinehart, New York, rev. ed., 1957. 614 pp. $6.50.

Trophoblastic Growths. Aclinical, hormonal, and histopathologic study of hydatidiform mole and chorionepithelioma. J. Smalbraak. Elsevier, Amsterdam, 1957. 354 pp. $12.75.

About Earthquakes. G. A. Eiby. Harper, New York, 1957. 168 pp. $3.

Advances in Enzymology and Related Subjects of Biochemistry. vol. XVIII. F. F. Nord, Ed. Interscience, New York, 1957. 440 pp. $9.

Nuclear Engineering. Charles F. Bonilla, Ed. McGraw-Hill, New York, 1957. 861 pp. $12.50.

The Making of a Moon. The story of the earth satellite program. Arthur C. Clarke. Harper, New York, 1957. 205 pp. $3.50.

Principles of Stratigraphy. Carl O. Dunbar and John Rodgers. Wiley, New York; Chapman & Hall, London, 1957. 356 pp. $10.

Pain and Pleasure. A study of bodily feelings. Basic Books, New York, 1957. 317 pp. $5.50.

The Caricature of Love. A discussion of social, psychiatric, and literary manifestations of pathologic sexuality. Hervey Cleckley. Ronald, New York, 1957. 329 pp. $6.50.

Experiments in Biochemical Research Techniques. Robert W. Cowgill and Arthur B. Pardee. Wiley, New York; Chapman & Hall, London, 1957. 198 pp. $3.50.

Miscellaneous Publications

(Inquiries concerning these publications should be addressed, not to Science, but to the publisher or agency sponsoring the publication.)

A Study of AEC Procedures and Organization in the Licensing of Reactor Facilities. 218 pp. *Development of Scientific, Engineering, and Other Professional Manpower* (with emphasis on the role of the Federal Government). 172 pp. Joint Committee on Atomic Energy, 85th Congress, 1st session. U.S. Government Printing Office, Washington 25, 1957.

The Nature of Shield Abnormalities in the Turtle Shell. Fieldiana, Geology, vol. 10, No. 29. Rainer Zangerl and Ralph G. Johnson. 22 pp. $0.60. *Notes on Amphibians and Reptiles from El Salvador* Fieldiana, Zoology, vol. 34, No. 42. A. Stanley Rand. 30 pp. $0.50. *Report on a Collection of Marine Fishes from North Borneo.* Fieldiana: Zoology, vol. 36, No. 3. Robert F. Inger. 65 pp. $1. *The Subspecies of the Bush Shrike.* Laniarius fulleborni (including L. poensis). Fieldiana, Zoology, vol. 39, No. 6. Austin L. Rand. 4 pp. $0.10. *Philippine Snails of the Family Endodontidae.* Philippine Zoological Expedition, 1946–1947. Fieldiana Zoology, vol. 41, No. 1. Alan Solem. 13 pp. $0.40. Chicago Natural History Museum, Chicago, 1957.

Improving the Organization and Management of Your Engineering and Research and Development Departments. Wallace Clark & Co., 521 Fifth Avenue, New York 17. Free.

The Thrips of California. pt. 1, *Suborder Terebrantia.* Bulletin, California Insect Survey, vol. 4, No. 5, pp. 143–220. Stanley F. Bailey. University of California Press, Berkeley, 1957. 78 pp. $1.50.

Meetings and Societies

Harvey Tercentenary

William Harvey, the discoverer of the circulation of the blood, died on 3 June 1657. Probably there has never been, since that date, an occasion more suitable than the present for a complete "Review of the present knowledge of the circulation," the theme which dominated and guided the discussions of the Harvey Tercentenary Congress in London, 3–8 June 1957. It is only during the past 30 years that methods have been introduced whereby the varying composition of the blood in different parts of hitherto inaccessible vessels can be accurately ascertained. The polythene catheter (a comparatively recent invention), introduced into a superficial vein, can safely be passed into the venae cavae and into the heart itself to provide necessary samples of blood. Comparatively recent, also, is the development of arteriography whereby, after the injection of radioopaque substances into the blood stream, radiographs will give accurate and detailed pictures of the distribution of the arterial supply. This has proved to be of vital importance in the diagnosis of many conditions which previously could only be found after surgical exploration. Moreover, during the past three decades considerable advances have taken place in the recording and interpretation of the electrical changes which occur in different cardiac conditions.

The most striking and revolutionary advances have, however, taken place in the surgery of the heart and the great blood vessels. All who were privileged to attend the congress sessions on the surgery of the heart and the surgery of the peripheral circulation must have been aware that operations can now be successfully performed which 30 years ago would have been deemed foolhardy and impossible. This has been made possible by many improvements, of which the outstanding advance is that of the production of hypothermia. A priori, the lowering of the temperature of the body should be harmful and add to the shock of an operation. Practically, it makes possible certain operations on the heart and large blood vessels by slowing down all the activities of the body, and, by lessening the demand for blood, diminishing the force and volume of the blood flow. Hypothermia, however, has itself only been rendered possible by the introduction of drugs which, when given to the patient, paralyze the muscles and prevent the violent shivering which would otherwise inevitably follow.

A consideration of the foregoing facts will enable readers to see how appropriate and even necessary was the congress which met early in June. The meetings were held mainly in the spacious halls of the Royal College of Surgeons. There were nine scientific sessions, all interesting and informative. The opening session, after an interesting talk on Harvey by the president, Dickson Wright, consisted of a historical review to which contributions were made by J. F. Fulton, K. J. Franklin, Charles Dodds, and F. A. Willius (whose paper was read *in absentia*). Franklin's contribution to the congress was much greater than the mere giving of a paper. At the request of the Royal College of Physicians, he had made a new, elegant, and accurate translation of the *De Motu Cordis*, which, happily, was published in time for the congress. At the commemorative dinner at the Dorchester Hotel, every man present was presented with a copy of this, the latest (and we think the best) translation of this epoch-making book.

At the second session, with Pickering in the chair, the speakers were L. W. Katz, K. Matthes, and Weidmann, who considered varied aspects of the role of the heart in circulation. The discussion was followed by a film, made by Paul Wood, which showed the jugular venous pulse.

On the second day, the morning session was taken up by consideration of hemodynamics. Heymans, of Ghent, discussed the role of the aortic and carotid sinus baroreceptors, and Gustav Nylin gave the results of his studies, in which, by following the fate of labeled erythrocytes, the variations in the blood flow in the heart, lungs, and brain are revealed. The afternoon session dealt with the coronary circulation, and here the chairman, Claude S. Beck of Cleveland, Ohio, described and explained the well-known operation for improving the coronary circulation which he advocates. G. A. Mason described his modification of the operation.

The morning of the third day was occupied by a discussion on the pulmonary circulation, in which André Cournaud was the chief speaker. In the afternoon there took place what was perhaps the most remarkable medical meeting ever held. The subject was the "Results of cardiac surgery," and Clement Price Thomas was in the chair. G. d'Allaines spoke first, on the results of the surgical treatment of mitral stenosis. Then followed J. M. H. Campbell, who considered, from the physician's point of view, the results of surgical treatment of coarctation of the aorta and pulmonary stenosis. Finally, in a masterly address, Russell Brock gave a detailed account of the results of his own operations for pulmonary stenosis. These papers were memorable in themselves, but what made the meeting unique was the introduction, by means of transatlantic radiotelephone, of a discussion between a panel of British speakers on the platform and a panel of equally eminent men speaking from the New York annual meeting of the American Medical Association. Enlarged photographs of the members of the American panel were in full view of the audience, and a red light indicated who was speaking. The voices came through well and were easily audible to all members of the audience. This session, by itself, would make the congress memorable.

The fourth day of the congress was occupied by discussions on the cerebral and splanchnic circulation. Sheila Sherlock gave an able paper on the portal circulation and portal hypertension, which was followed by an eloquent address by Milnes Walker who, basing his doctrine on his own experience, laid down clear indications and contraindications for the operative treatment of portal hypertension.

The final scientific session was devoted to the peripheral circulation. Barcroft considered the physiology of the peripheral circulation. He showed that factors other than nervous reflexes were concerned and explained how the local effect of warmth in the skin was to release a substance (which has been called "bradykinin") which causes a dilatation of the blood vessels and increases the secretion of sweat. Paton discussed the innervation of the blood vessels and Dible discussed their pathological changes. The final paper of this session was that of Rob, who gave the results obtained in his clinic by the operative treatment of occlusive arterial disease; this address —clear, concise, and moderate in tone but remarkable in the results demonstrated—was a fitting conclusion to the

last session. In the afternoon, Russell Brain brought the scientific congress to an end by a well-delivered and appropriate address.

In between the scientific meetings, and each day after they were concluded, many ceremonial and social functions occupied the attention of the members of the congress. There were receptions given by Her Majesty's Government and by the Royal College of Physicians, a banquet at the Dorchester Hotel, and a reception given by the Harveian Society at Gray's Inn (of which William Harvey was a member), and there were special meetings of the Osler Club and of the historical section of the Royal Society of Medicine, at which an address written by Fulton was read for him.

William Harvey was born at Folkestone and had his schooling at King's College School, Canterbury. A special meeting was held on Saturday, 8 June, at Folkestone, over which Geoffrey Keynes presided and at which a series of very interesting papers, with many new facts, was presented.

On Saturday afternoon, many members of the congress attended a special service held at Canterbury Cathedral, at which the present headmaster of the school which Harvey attended as a boy preached the sermon. In the evening there was a commemorative dinner at the Hotel Metropole in Folkestone, and on Sunday morning, after matins at the parish church, a procession was formed and proceeded to the statue of William Harvey, at the foot of which a commemorative wreath was laid.

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Kansan Glaciation in Indiana

The eighth annual field conference of the Midwestern Friends of the Pleistocene was held 26–28 Apr. in south-central Indiana. Headquarters were at Indiana University, Bloomington. The field trips were under the leadership of William D. Thornbury (department of geology, Indiana University) and William J. Wayne (Indiana Geological Survey). The conference was attended by about 87 people, mainly geologists and soil scientists, from Colorado, Iowa, Minnesota, Nebraska, Illinois, Wisconsin, Indiana, Ohio, Michigan, the District of Columbia, and Ontario.

The major objective of the field conference was to present evidence of extensive Kansan glaciation in Indiana. Exposures of Kansan till, loess, and lacustrine deposits indicate a striking similarity in the extent of Kansan and Illinoian glaciation in Indiana. Ice lobes extended into southwestern and southeastern Indiana during both glaciations. In one known locality, Kansan till is the outermost till, and it is therefore no longer safe to assume that the glacial boundary in Indiana everywhere coincides with the limits of Illinoian glaciation. It seems probable, now, that the erratics in Kentucky that were described by Frank Leverett in "The Pleistocene of northern Kentucky" [*Kentucky Geol. Survey ser. 6* **31**, 1 (1929)] are Kansan in age rather than Nebraskan, as was suggested by F. T. Thwaites in *Outline of Glacial Geology* [Edwards, Ann Arbor, Mich. (1946), plate 3].

The field conference also included the observation of several sections in which buried soils, developed upon Illinoian drift, are exposed, as well as two points at which Wisconsin interstadial silts and organic material separate two early Wisconsin (presumably Shelbyville and Champaign) tills, whose exact age determination awaits radiocarbon dating.

WILLIAM D. THORNBURY
Indiana University, Bloomington

NSF Supports Travel to Pacific Science Congress

The National Science Foundation is cooperating with the Pacific Science Board of the National Academy of Sciences in the support of travel of American scientists to the 9th Pacific Science Congress to be held in Bangkok, Thailand, 18 Nov.–9 Dec. Because of the limitation in availability of funds, the number and size of awards will be extremely small. Those interested should apply by letter to the Pacific Science Board, National Academy of Sciences, 2101 Constitution Ave., Washington 25, D.C., *no later than 31 Aug.* No special application blanks are necessary. Applicants will be screened by a joint committee in early September and those recommended for grants will be notified by the foundation on approximately 15 Sept.

Free Radicals Symposium

Twenty technical papers are scheduled for presentation at the Symposium on the Formation and Stabilization of Free Radicals, to be held at the National Bureau of Standards, 18–20 Sept. Sponsored jointly by NBS, the University of Maryland, the Catholic University of America, and the Applied Physics Laboratory of Johns Hopkins University, the meeting will be devoted primarily to discussions of current research on the properties of systems containing trapped atoms and radicals. This new field of study is expected to have important applications in both science and engineering.

Because of the limited seating capacity of the NBS auditorium, attendance at the symposium is by invitation, and preregistration is required. Inquiries should be addressed to the chairman of the symposium committee, Dr. A. M. Bass, Free Radicals Research Section, National Bureau of Standards, Washington 25, D. C.

International Congress of Radiology

The ninth International Congress of Radiology will be held in Munich, Germany, from 23 to 30 July 1959. The international committee for the congress has elected Boris Rajewsky, Frankfurt am Main, Germany, as president. The general secretary is Hans v. Braunbehrens, Munich. Viktor Loeck is executive secretary of the congress. Further information may be obtained from the *Kongressekretariat, Forsthausstrasse 76, Frankfurt am Main, Germany.*

Forthcoming Events

September

1–6. Laurentian Hormone Conf., AAAS, Mont Tremblant, Quebec, Canada. (G. Pincus, LHC, 222 Maple Ave., Shrewsbury, Mass.)

1–7. Psychiatry, 2nd world cong., Zurich, Switzerland. (J. Wyrsch, Tottikon, Stans, Nidwald, Switzerland.)

1–16. Aeronautical Conf., 6th internatl., London and Folkestone, Kent, England. (S. P. Johnston, Inst. of Aeronautical Sciences, 2 E. 64 St., New York 21.)

2–5. American Physiological Soc., Iowa City, Iowa. (M. O. Lee, 9650 Wisconsin Ave., Washington 14.)

2–5. Passivity, internatl. symp., Darmstadt, Germany. (German Bunsen Gesellschaft, Postfach 11, Duisburg, Germany.)

2–6. Operational Research, internatl. conf., Oxford, England. (T. Page, 7100 Connecticut Ave., Chevy Chase, Md.)

2–16. Carbon-14 Dating, 3rd internatl. conf., in conjunction with INQUA, Madrid-Barcelona, Spain. (M. Rubin, U.S. Geological Survey, Washington 25.)

2–16. International Assoc. on Quarternary Research, 5th internatl. cong., Madrid-Barcelona, Spain. (M. L. Solé Sabarís, Instituto Geológico, Universidad, Barcelona.)

3–4. Meteoritical Soc., 20th annual, Los Angeles, Calif. (J. A. Russell, 3518 University Ave., Los Angeles 7.)

3–6. Calorimetry Conf., 12th, Wentworth-by-the-Sea, N.H. (H. A. Boorse, Pupin Physics Lab., Columbia Univ., New York, N.Y.)

3–6. Matrix Computations Conf., Detroit, Mich. (W. Givens, Dept. of Mathematics, Wayne State Univ., Detroit 2.)

3–14. International Union of Geodesy and Geophysics, 11th general assembly, Toronto, Ont., Canada. (J. A. Jacobs, 49 St. George St., Toronto.)

4–5. Society of General Physiologists,

annual, Woods Hole, Mass. (A. M. Shanes, NIH, Bethesda 14, Md.)

4–6. Latency and Masking in Viral and Rickettsial Infections, symp., Madison, Wis. (A. S. Evans, Div. of Preventive Medicine, Univ. of Wisconsin Medical School, Madison 6.)

4–6. Magnetic Amplifiers, technical conf., Pittsburgh, Pa. (G. F. Pittman, Jr., Westinghouse Electric Corp., P. O. Box 10596, Pittsburgh 35.)

4–7. American Soc. for Pharmacology and Experimental Therapeutics, Baltimore, Md. (P. K. Smith, George Washington Univ. School of Medicine, Washington 5.)

4–11. British Assoc. for the Advancement of Science, 119th annual, Dublin, Ireland. (Secretary, BAAS, Burlington House, London, W.1, England.)

5–7. American Physical Soc., Boulder, Colo. (W. A. Nierenberg, Univ. of California, Berkeley 4.)

5–7. American Political Science Assoc., natl., New York, N.Y. (E. M. Kirkpatrick, APSA, 1726 Massachusetts Ave., NW, Washington 6.)

6–12. Medicine and Social Hygiene, internatl. symp., Trieste. (M. Lovenati, via Cavana 18, Trieste.)

7–14. Odontostomatology, 12th internatl. cong., Rome, Italy. (G. Corradi, 16 via Boezio, Rome.)

7–14. Sociology, 17th internatl. cong., Beirut, Lebanon. (G. Gini, via Adige 39, Rome, Italy.)

8–12. International College of Surgeons, 22nd annual, Chicago, Ill. (K. A. Meyer, ICS, 1516 Lake Shore Dr., Chicago 10.)

8–13. American Assoc. of Clinical Chemists, annual, New York, N.Y. (M. M. Friedman, Lebanon Hospital, New York 57.)

8–13. American Chemical Soc., New York, N.Y. (A. H. Emery, ACS, 1155 16 St., NW, Washington 6.)

8–13. Nuclear Structure, internatl. conf. (IUPAP), Rehovoth, Israel. (A. de Shalit, Weizmann Inst. of Science, Rehovoth.)

8–15. International Cong. of Crop Protection, 4th, Hamburg, Germany. (Biologische Bundesanstalt für Land- und Forstwirtschaft, Messeweg 11–12, Braunschweig, Germany.)

9–11. Electron Microscope Soc. of America, annual, Cambridge, Mass. (D. M. Teague, Chrysler Corp., Box 1118, Detroit 31, Mich.)

9–11. Quantitative Methods of Mammalian Cell Culture, 2nd annual, Denver, Colo. (Office of Graduate and Postgraduate Education, Univ. of Colorado Medical Center, Denver 20.)

9–13. Illuminating Engineering Soc., annual, Atlanta, Ga. (A. D. Hinckley, IES, 1860 Broadway, New York 23.)

9–13. Instrument Automation Conf., 12th annual, Cleveland, Ohio. (Instrument Soc. of America, 313 Sixth Ave., Pittsburgh, Pa.)

9–13. Neutron Interaction with Nuclei, internatl. conf. of IUPAP, New York. (W. W. Havens, Pupin Cyclotron Lab., Columbia Univ., 538 W. 120 St., New York 27.)

9–15. Macromolecular Chemistry, internatl. symp., IUPAC, Prague, Czechoslovakia. (Secretariat, ISMC, 5, Technická, Prague 6.)

9–20. Radio-Isotopes in Research, UNESCO conf., Paris, France. (UNESCO House, 19, avenue Kléber, Paris 16e.)

10–13. Alaskan Science Conf., 8th, Anchorage. (C. J. Beers, U.S. Coast and Geodetic Survey, College, Alaska.)

10–13. American Statistical Assoc., annual, Atlantic City, N.J. (D. C. Riley, ASA, 1757 K St., NW, Washington 6.)

10–13. Biometric Soc., Eastern North American region, Atlantic City, N.J. (A. M. Dutton, Box 287, Sta. 3, Rochester, N.Y.)

10–13. Econometric Soc., Atlantic City, N.J. (R. Ruggles, Dept. of Economics, Yale Univ., New Haven, Conn.)

10–13. Institute of Mathematical Statistics, annual, Atlantic City, N.J. (G. E. Nicholson, Jr., Dept. of Statistics, Univ. of North Carolina, Chapel Hill.)

14–15. Minnesota Acad. of Science, Cedar Creek Forest. (M. R. Boudrye, 51 University Ave., St. Paul 3, Minn.)

15–18. American Inst. of Chemical Engineers, natl., Baltimore, Md. (F. J. Van Antwerpen, AIChE, 25 W. 45 St., New York 36.)

16–21. Orthopedic Surgery and Traumatology, 7th internatl. cong., Barcelona, Spain. (J. M. Vilardell, Avenida Jose Antonio 654, Barcelona.)

(See issue of 19 July for comprehensive list)

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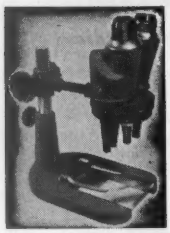

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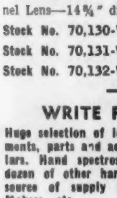

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■ QUADRUPLE-BEAM OSCILLOSCOPE is linear to ±0.5 db from direct current to 100 kcy/sec. Input may be either differential or single-ended. Features include automatic amplitude calibration, four-step sequence timer, crystal-controlled timing pulse, and provision for synchronization and control of recording cameras. (Electronic Tube Corp., Dept. S462)

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2nd printing July 1957

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■ ULTRASONIC GENERATOR for therapeutic applications features a transducer incorporating a 10-cm² quartz crystal. Total dosage intensity is 30 w, with no energy being reflected back into the hand of the operator. The unit complies with all FCC requirements on minimum conducted line and radiation interference. (Dakon Tool and Machine Co., Inc., Dept. S492)

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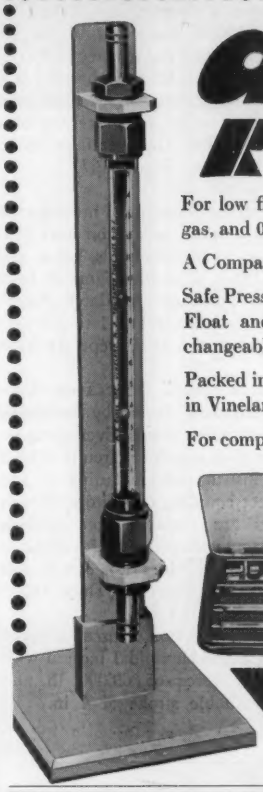

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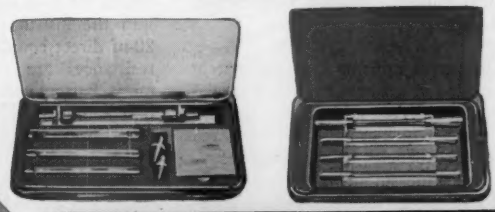

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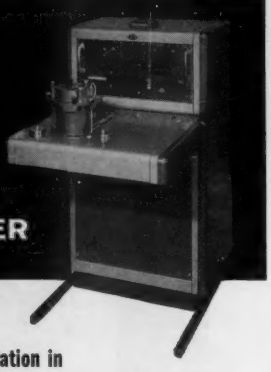

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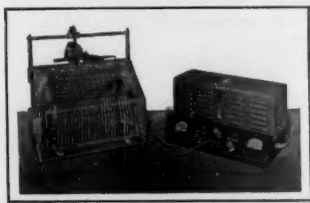

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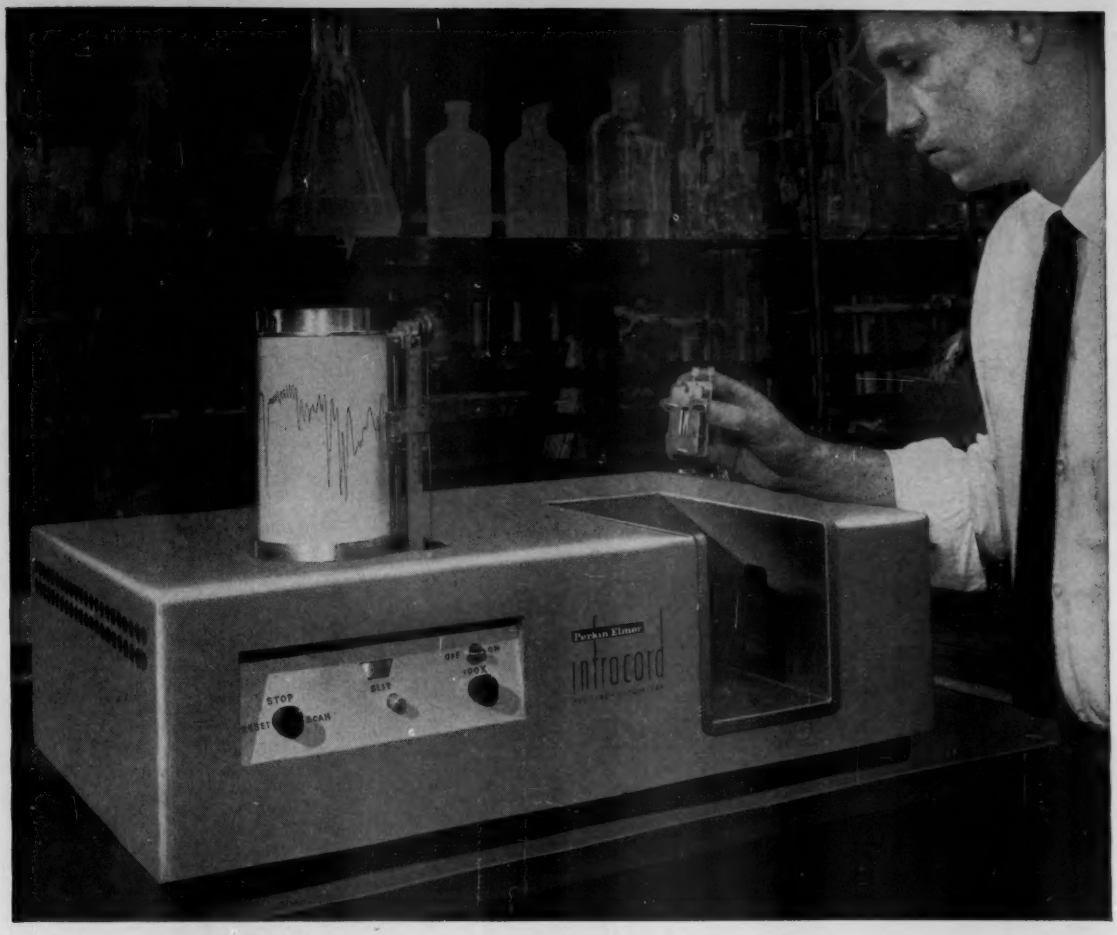

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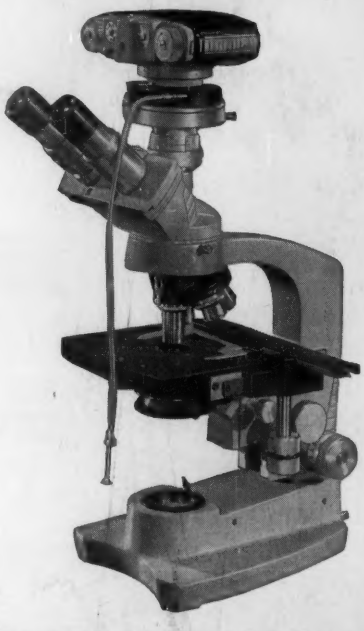

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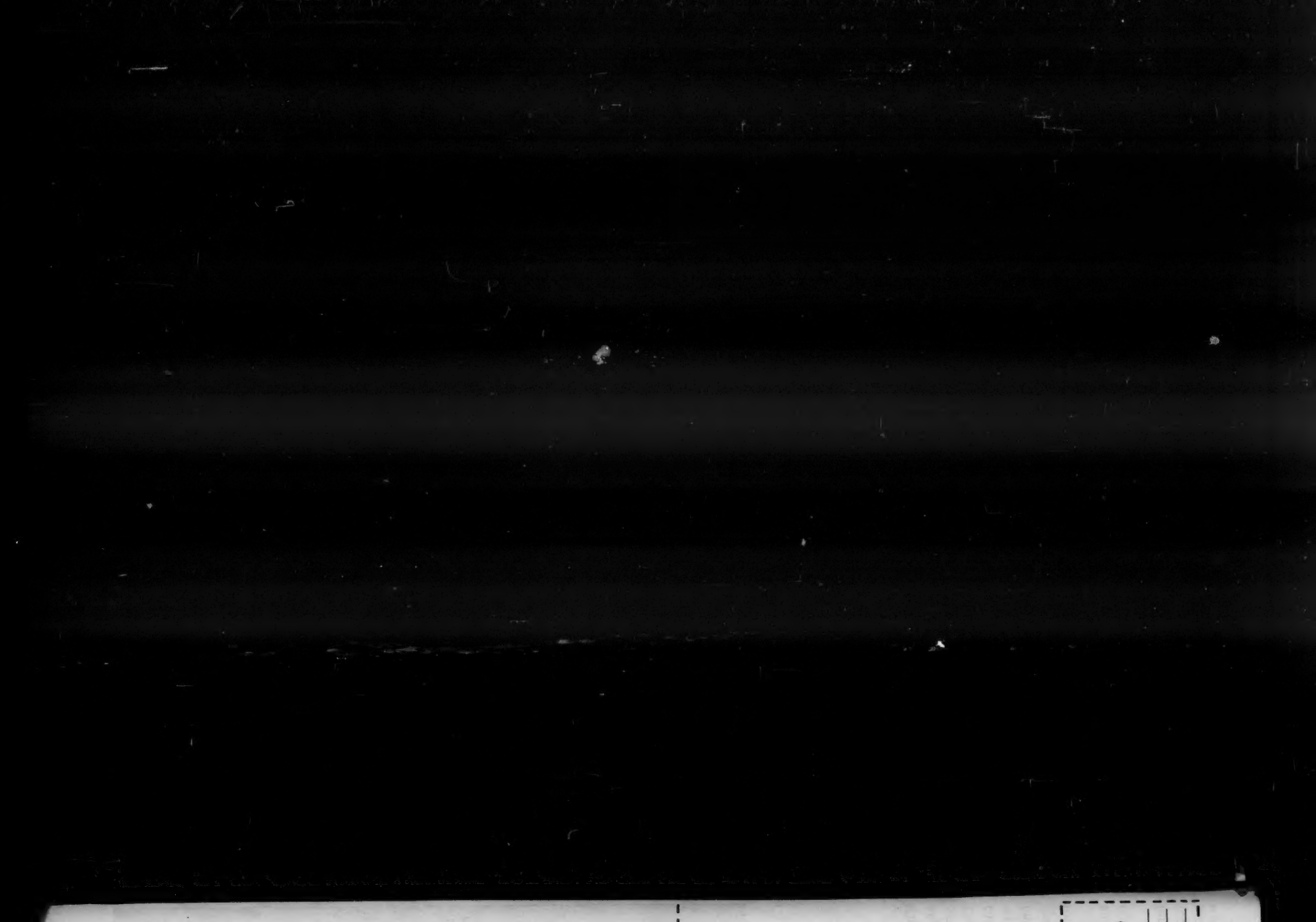
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